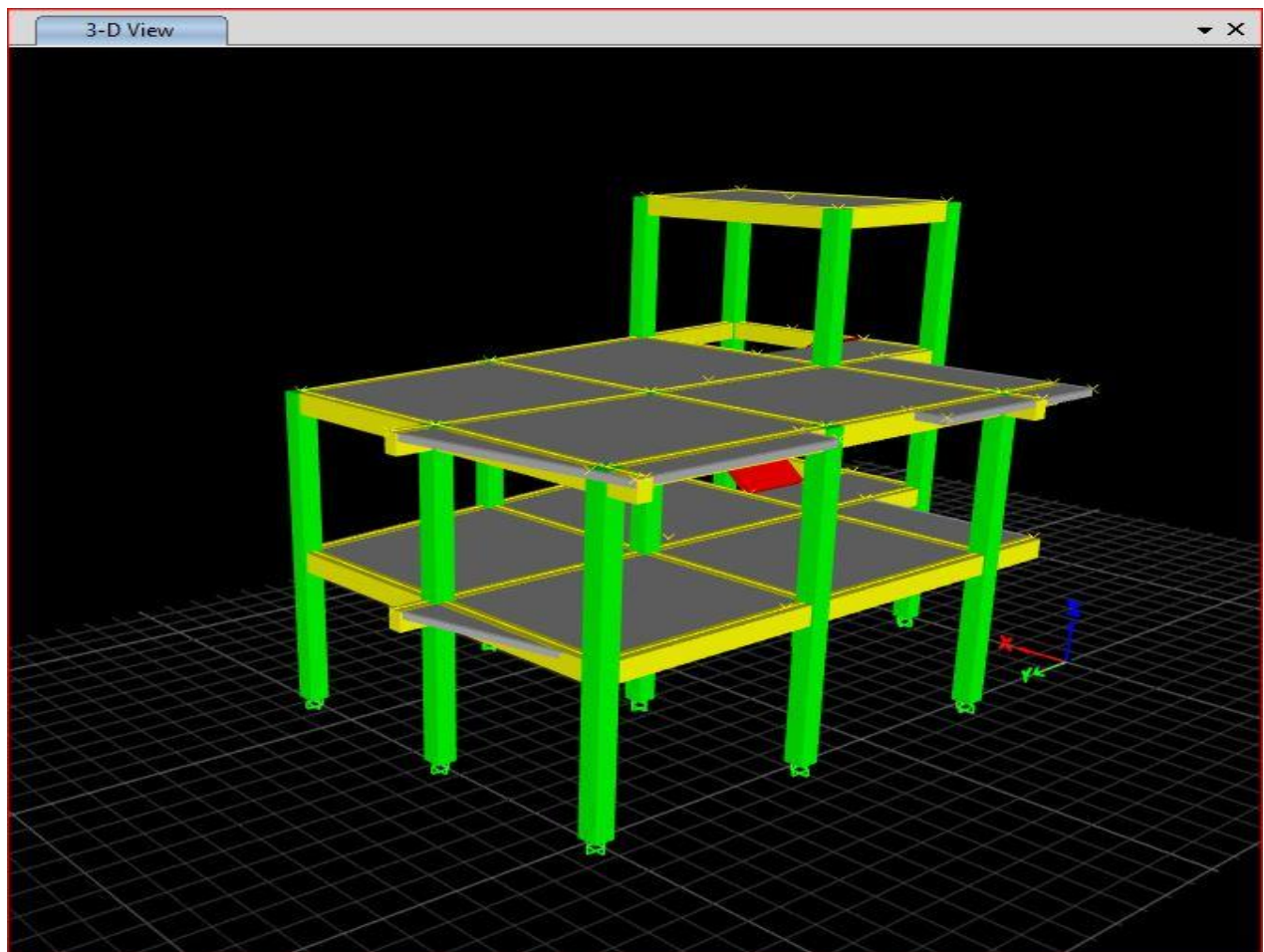


STRUCTURAL ANALYSIS AND DESIGN OF RESIDENTIAL BUILDING



04 JUL, 2023

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KABILASI-10, SARLAHI

Table of Contents

1.	Project Details	1
2.	Structural Feature	2
2.1	Foundation	2
2.2	Framing Description:	3
3.	Codes and Standards	3
4.	Materials (Characteristics)	4
5.	Soil Bearing Capacity	4
6.	Loads	4
6.1	Dead Load:	4
6.2	Imposed Load:	4
6.3	Earthquake Load:	5
7.	Load Combinations	7
8.1	Method:	8
8.2	Conditions:	8
9.	Input Data	8
13.	General Notes	55
14.	References	56

Appendix:**I) Abbreviations:****NOTATIONS:****SYMBOLS****DESCRIPTION**

A_c	: Area of concrete
A_g	: Gross area of section
A_{st}	: Area of tensile steel
A_{sc}	: Area of compression steel
A_{sv}	: Area of vertical stirrups
b	: Width of beam or shortest dimension of column
D	: Overall depth of a beam or slab
d	: Effective depth of a beam or slab
e_{min}	: Minimum eccentricity
f_{ck}	: Characteristic compressive strength of concrete
f_{sc}	: Compressive stress in steel corresponding to a strain 0.002
f_{st}	: Tensile stress in reinforcement
f_y	: Characteristic yield strength of steel
L_d	: Development length of bar
L	: Length of column or span of beam
L_o	: Anchorage length of bar
L_{eff}	: Effective length of beam or column
M_u	: Factored design moment
$M_{u,lim}$	: Limiting moment of resistance
M_{ux}	: Factored design moment along x-x Axis
M_{uy}	: Factored design moment along y-y Axis
$M_{ux,l}$	: Maximum uniaxial moment capacity with axial load, bending about x-x axis
$M_{uy,l}$	: Maximum uniaxial moment capacity with axial load, bending about y-y axis

I	: Moment of inertia of a section
I_x, I_y	: Moment of inertia about X and Y axis
P	: Axial load
P_u	: Factored design axial load
p_t	: Percentage of tension reinforcement
S_v	: Spacing or vertical stirrups
V	: Shear force
V_u	: Factored shear force
V_{us}	: Design strength of shear reinforcement
τ_c	: Shear stress in concrete
τ_v	: Nominal shear stress
τ_{bd}	: Design bond stress
$\tau_{c, \max}$	: Maximum shear stress in concrete with shear reinforcement
Φ	: Diameter of bar
$A_{st, req}$	: Required area of tensile steel
$A_{sc, req}$	: Required area of compression steel
$A_{st, Pro}$	: Provided area of tensile steel
$A_{sc, Pro}$	: Provided area of compression steel
$S_{v, prov}$	: Provided spacing of vertical stirrups
W	: Total unfactored Load
w	: Total Factored Load
L_y	: Effective length of slab in longer direction
L_x	: Effective length of slab in shorter direction
k	: Constant or coefficient or factor
p	: Calculated maximum bearing pressure of soil

1. Project Details

Name of the Project : Structural Analysis and Design of **Residential** Building
Name of Owner :
Location : Sitapaila, Nagarjuna municipality
Type of Building : Residential Building

The building is a two and half story Residential building on **Isolated footing** with a flat RC terrace.

Total Height of the Building : 28'-0"
Lateral Dimension of the Building : 32'-6" x 24'-0"
Floor Height : 9'-4"
Total No. of Staircase : one dog-legged staircase upto top floor

General Information:

1. **Structural Analysis Software** :- ETABS 2019
2. **Structural System** :- RCC Frame
3. **Foundation System** :- **Isolated Footing**

4. Load parameter

- a. Dead Load :- as per IS 875:1987 Part I
- b. Live Load :- as per IS 875:1987 part II
- c. Seismic Load :- as per IS 1893 :2002
 - i. Zone Factor :- 0.35 NBC table 4-5 as per municipalities

2.2 Framing Description:

2.2.1 Beam

Size: All the beams at floor level are of size 9"x 14".

Location/Orientation: All the beams are concentric with the columns. i.e. the center line of beams match with that of column's center line. It is to be noted that the side surface of beams may be matched with surfaces of walls/partitions by additional concrete as required in architectural drawings.

2.2.2 Column:

Size: Basically the column used in the building is of Rectangular size 12"x12"

2.2.3 Slab:

Size: Concrete slab 5" thick is provided at the floor level. For staircase, thickness of concrete slab is also 150mm.

3. Codes and Standards

The main design standards followed for structural design are given below, indicating their area of application.

S.N.	Code and Standards	Description
1	NBC 105:2020	<i>Seismic Design of Buildings in Nepal</i>
2	IS 456: 2000	<i>Plain and Reinforced Concrete - Code of Practice</i>
3	IS 875 (Part 1): 1987	<i>Code of Practice for Design Loads (other than Earthquake) for Buildings and Structures: Part 1 Dead Loads – Unit Weights of Building Material and Stored Materials (Second Revision)</i>
4	IS 875 (Part 2): 1987	<i>Code of Practice for Design Loads (other than Earthquake) for Buildings and Structures: Part 2 Imposed Loads (Second Revision)</i>
5	IS 875 (Part 3): 1987	<i>Code of Practice for Design Loads (other than Earthquake) for Buildings and Structures: Part 3 Wind Loads (Second Revision)</i>
6	SP 34: 1987	<i>Handbook on Concrete Reinforcement and Detailing</i>
7	IS 13920: 1993	<i>Ductile detailing of reinforced concrete structures subjected to seismic forces - Code of practice</i>
8	IS 1893: 2002	<i>Criteria for Earthquake Resistant Design of structures</i>

9	IS 1786: 1985	<i>Specification for high strength deformed steel bars and wires for concrete reinforcement (superseding IS:1139 -1966)</i>
10	SP 16 : 1980	<i>Design Aids for Reinforced Concrete to IS 456 : 1978</i>

4. Materials (Characteristics)

Concrete:

All the structural elements are of grade **M20** to IS 456:2000. As per annex A of NBC105:2020, minimum grade of structural **concrete M25 is need if the height of the structure exceeds 12m.**

Reinforcement Bar:

- Reinforcement bars are to be in accordance with IS 456: specification for carbon steel bars for the reinforcement of concrete is to be in accordance with IS 1786: specification for high deformed steel bars for the reinforcement of concrete
- High strength deformed steel bars: Grade Fe 500 to IS 1786 is to be provided.

5. Soil Bearing Capacity

The soil bearing capacity shall not be less than 150 kN/m².

Conformation test is required before starting the work.

6. Loads

6.1 **Dead Load:**

All loads/forces due to gravity on the components of the building structure including the structures self-weight, roofing, flooring, suspended ceiling, wall/partition, services including machinery, piping, rack with all associated finishing permanently attached thereto are calculated in accordance with IS: 875 (Part 1) - 1987.

6.2 **Imposed Load:**

The load assumed to be produced by the intended use and occupancy of a building, including the loads of movable partition, impact, vibration, and dust, but excluding wind, seismic, snow and other loads due to temperature changes, creep, shrinkage, differential settlement, etc., in accordance with IS 875 (Part 2) – 1987.

6.3 Earthquake Load:

The earthquake load is calculated by the linear static coefficient method using equivalent lateral force procedures in accordance with NBC105:2020. The static analysis is followed as per Cl 3.2.1 which states that equivalent static method may be used when at least one of the following criteria is satisfied

- a) The height of the structure is less than or equal to 15m. (Satisfied for our structure)
- b) The natural time period of the structure is less than 0.5sec. (Satisfied for our structure)
- c) The structure is not categorized as irregular and height is less than 40m.(Not Satisfied for our structure)

As all case are satisfies for the structure, response spectrum aren't required.

The static forces in the structure are derived from the design base shear (V_b) calculated for both the ultimate limit state and Serviceability limit state:

Elastic Site Spectra				
Ultimate Limit State				
C(T)	=		Ch(T)*Z*I	
Z	=		0.35	
I	=		1	
Ch(T)	=		2.25	
C(T)	=		0.7875	
Ductility factor	=		4	
Overstrength Factor	=		1.5	
Cd(T1)	=		0.131	
Serviceability Limit State				
Ca(To)	=		0.1575	
Ductility factor	=		1	
Overstrength Factor	=		1.25	
Cd(T2)	=		0.126	
Time Period Calculation				
Empirical				
h		8.534	m	
T		0.374	sec	
Time Period after amplificat		0.468		

(Note: For the Building, the type of soil is categorized to be medium soil (Type II) as per Cl. 6.3.5.2)

The approximate fundamental natural period of vibration (T_a), in seconds, of a moment resisting frame building without brick infill panels may be estimated by the empirical expression:

$$\begin{aligned} T_a &= 0.075 h^{0.75} \text{ for RC frame building} \\ &= 0.085 h^{0.75} \text{ for steel frame building} \end{aligned}$$

Where h = Height of building, in m.

Similarly, the approximate fundamental natural period of vibration (T_a), in seconds, of all other buildings, including moment-resisting frame buildings with brick infill panels, may be estimated by the empirical expression:

$$T_a = 0.09 \frac{h}{\sqrt{d}}$$

Where;

h = Height of building in m as defined in Cl.7.6.1.

d = Base dimension of the building at the plinth level in m, along the considered direction of the lateral force.

Distribution of earthquake load:

The design base shear (V_b) program calculated as per code IS 19893:2002).

Note: In calculating the seismic weight of floors, the full dead load at each storey is considered, while the imposed load is considered as per following criteria (IS 1893:2002, Table 8) (defined in Mass Source.)

Where seismic load effect is combined with other load effects and this structure is characterized as non-parallel system Hence, the following load combination shall be adopted.

$$1.2DL + 1.5LL$$

$$DL + \lambda LL \pm (E_x \pm 0.3E_y)$$

$$DL + \lambda LL \pm (0.3E_x \pm E_y) \dots \dots \dots (3.6.1)$$

Where, $\lambda = 0.6$ for storage facilities

$= 0.3$ for other usage For Roofs

- NIL

Seismic Weight and Time Period of the Building

TABLE: Load Pattern Definitions - Auto Seismic - User Coefficient													
Name	Is Auto Load	X Dir?	X Dir Plus Ecc?	X Dir Minus Ecc?	Y Dir?	Y Dir Plus Ecc?	Y Dir Minus Ecc?	Ecc Ratio	Top Story	Bottom Story	C	K	Weight Used
													kN
													kN
EQx_SLS	No	Yes	Yes	Yes	No	No	No	0.1	STAIR COVER	BASE	0.126	0.984	
EQx_SLS(1/3)	Yes	Yes	No	No	No	No	No	0.1	STAIR COVER	BASE	0.126	0.984	1734.1316
EQx_SLS(2/3)	Yes	No	Yes	No	No	No	No	0.1	STAIR COVER	BASE	0.126	0.984	1734.1316
EQx_SLS(3/3)	Yes	No	No	Yes	No	No	No	0.1	STAIR COVER	BASE	0.126	0.984	1734.1316
EQx_ULS	No	Yes	Yes	Yes	No	No	No	0.1	STAIR COVER	BASE	0.131	0.984	
EQx_ULS(1/3)	Yes	Yes	No	No	No	No	No	0.1	STAIR COVER	BASE	0.131	0.984	1734.1316
EQx_ULS(2/3)	Yes	No	Yes	No	No	No	No	0.1	STAIR COVER	BASE	0.131	0.984	1734.1316
EQx_ULS(3/3)	Yes	No	No	Yes	No	No	No	0.1	STAIR COVER	BASE	0.131	0.984	1734.1316
EQy_SLS	No	No	No	No	Yes	Yes	Yes	0.1	STAIR COVER	BASE	0.126	0.984	
EQy_SLS(1/3)	Yes	No	No	No	Yes	No	No	0.1	STAIR COVER	BASE	0.126	0.984	1734.1316
EQy_SLS(2/3)	Yes	No	No	No	No	Yes	No	0.1	STAIR COVER	BASE	0.126	0.984	1734.1316
EQy_SLS(3/3)	Yes	No	No	No	No	No	Yes	0.1	STAIR COVER	BASE	0.126	0.984	1734.1316
EQy_ULS	No	No	No	No	Yes	Yes	Yes	0.1	STAIR COVER	BASE	0.131	0.984	
EQy_ULS(1/3)	Yes	No	No	No	Yes	No	No	0.1	STAIR COVER	BASE	0.131	0.984	1734.1316
EQy_ULS(2/3)	Yes	No	No	No	No	Yes	No	0.1	STAIR COVER	BASE	0.131	0.984	1734.1316
EQy_ULS(3/3)	Yes	No	No	No	No	No	Yes	0.1	STAIR COVER	BASE	0.131	0.984	1734.1316

7. Load Combinations

For Design of concrete elements, the following load combination has been considered according to Nepal national building code (NBC 105:2020)

$$1.2DL+1.5LL$$

$$DL+0.3LL-0.3EQx_SLS+EQy_SLS$$

$$DL+0.3LL-0.3EQx_SLS-EQy_SLS$$

$$DL+0.3LL-0.3EQx_ULS+EQy_ULS$$

$$DL+0.3LL-0.3EQx_ULS-EQy_ULS$$

$$DL+0.3LL+0.3EQx_SLS+EQy_SLS$$

$$DL+0.3LL+0.3EQx_SLS-EQy_SLS$$

$$DL+0.3LL+0.3EQx_ULS+EQy_ULS$$

$$DL+0.3LL+0.3EQx_ULS-EQy_ULS$$

$$DL+0.3LL+EQx_SLS-0.3EQy_SLS$$

$$DL+0.3LL+EQx_SLS+0.3EQy_SLS$$

$$DL+0.3LL+EQx_ULS-0.3EQy_ULS$$

$$DL+0.3LL+EQx_ULS+0.3EQy_ULS$$

$$DL+0.3LL-EQx_SLS-0.3EQy_SLS$$

$$DL+0.3LL-EQx_SLS+0.3EQy_SLS$$

$$DL+0.3LL-EQx_ULS-0.3EQy_ULS$$

DL+0.3LL-EQx_ULS+0.3EQy_ULS

DL+LL (Footing)

8. Structural Analysis:

8.1 Method:

Type: All the Structural elements of reinforced concrete are designed to ultimate limit state and serviceability limit state

Program Used:

ETABS 2019 is used for the analysis and design of three-dimensional structures, in which the **linear static analysis from equivalent static method** is performed.

8.2 Conditions:

Since, all the columns are rigidly connected to the mat foundation; we can assume that there would be no any deflection or rotation of these columns at the base. Hence, the supporting conditions for column are fixed.

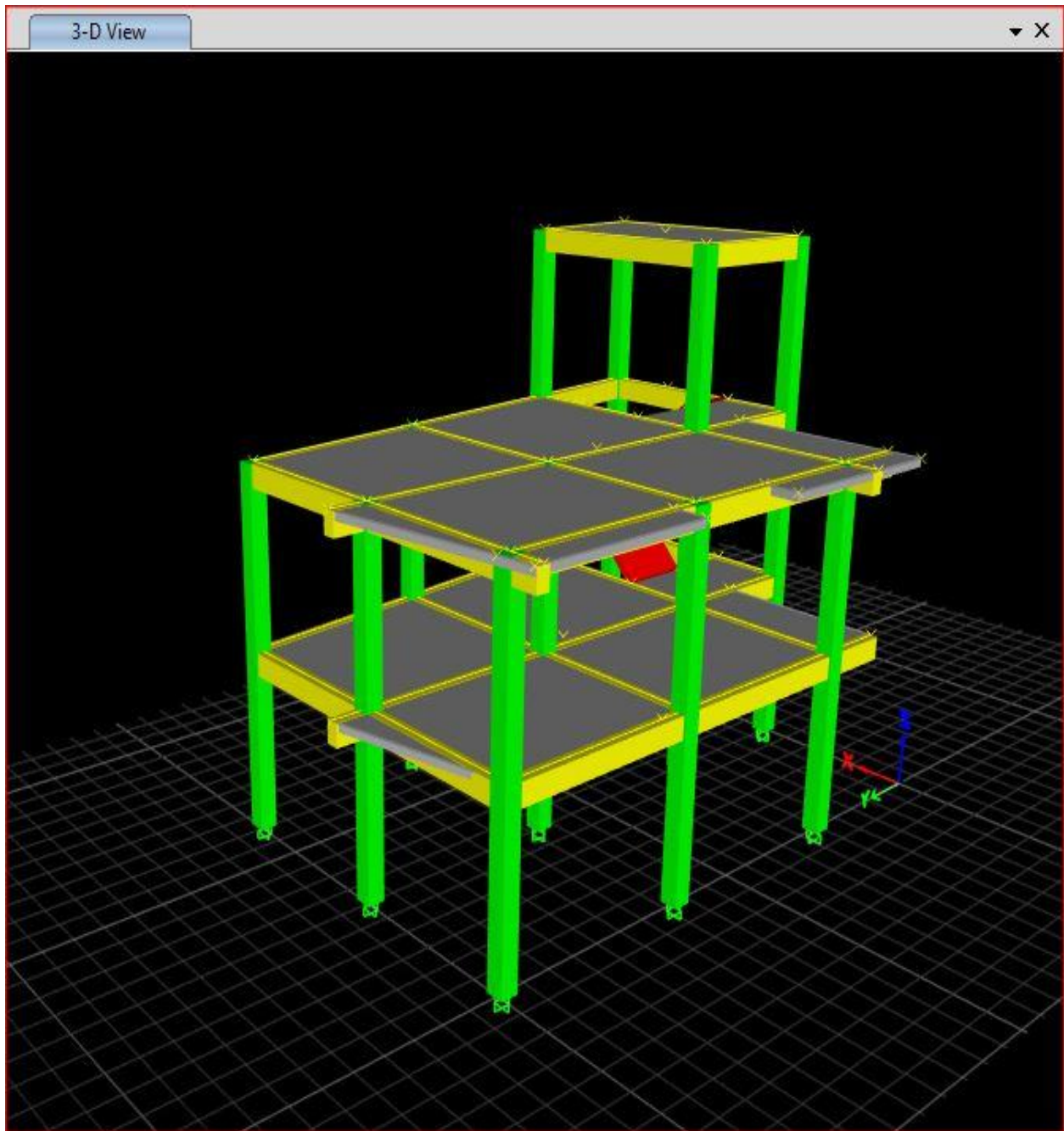
Similarly, at the level where the RC slab panels are rigidly connected to the beams, we assume that there would be equal displacement. i.e. **the concrete floor acts as a rigid floor diaphragm**.

9. Input Data

Generally, the design of structure in ETABS starts with the modeling of structure and then defining all the parameters required for the analysis and design (such as materials, conditions as mentioned above, loading information, codes and standards, etc.)

The input data for the design of structure generally includes the dead load (except the self-weight of structure presented in the model), the imposed load, the lateral loads, the wind load and other special loads (for example, loads due to thermal effects)

The 3D model of building is as shown below:



Dead loads are calculated on the basis of unit weights of the specified construction materials in accordance with IS 875.

9.2 Imposed (Live) load:

The live load for the building is extracted from the IS code 875 part II -1987 for different occupancies.

For Residential building

- 1.5 KN/m² for terrace
- 3 KN/m² for stair, passage,
- 0.75 KN/m² for not accessible roof.
- 2 KN/m² for room for others purpose.

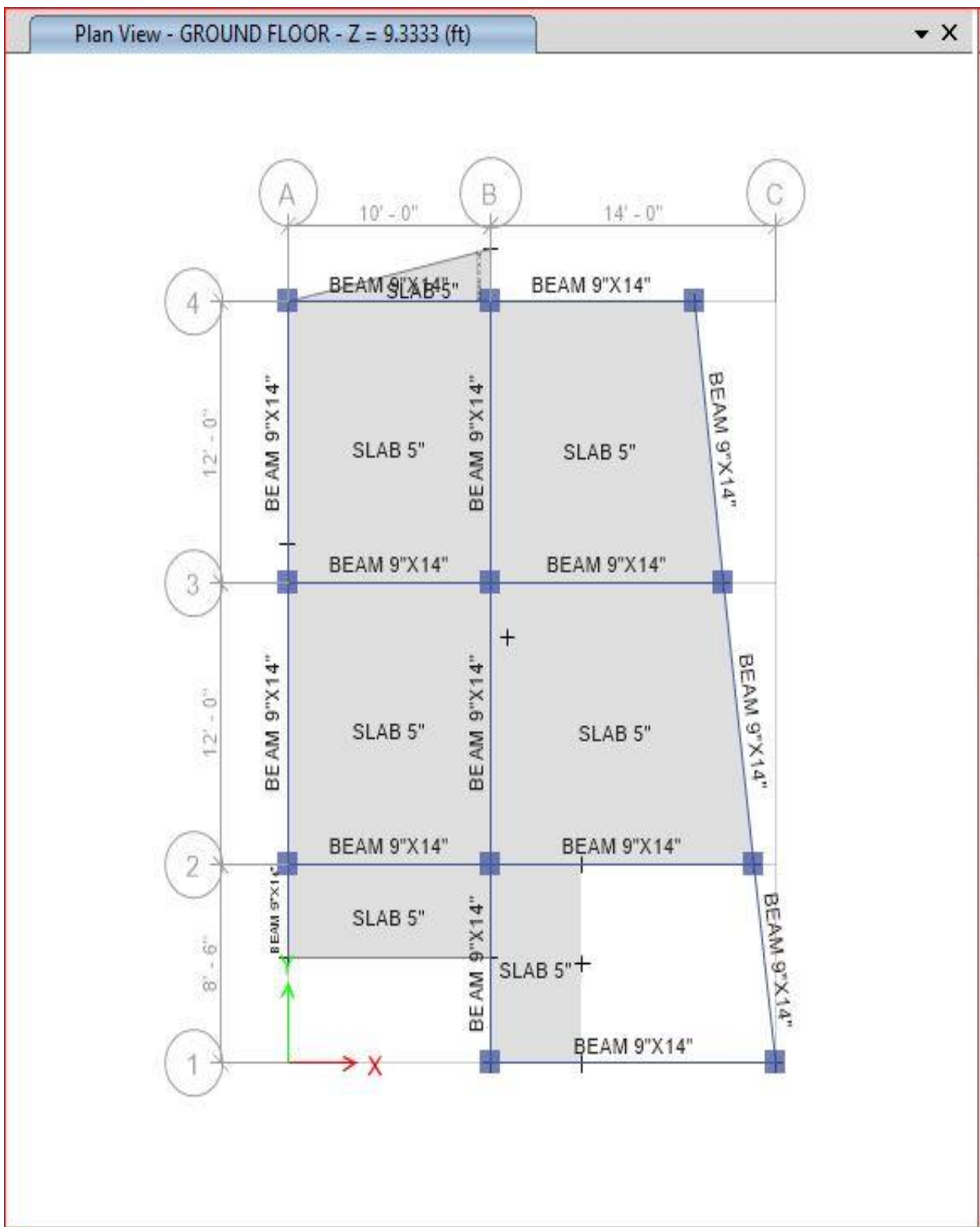
9.3 Lateral Loads:

ETABS automatically incorporates all the required calculations for lateral loads as per IS 1893:2002 based on the input data we provide. The required parameters for lateral load calculation has already been mentioned above in 6.3

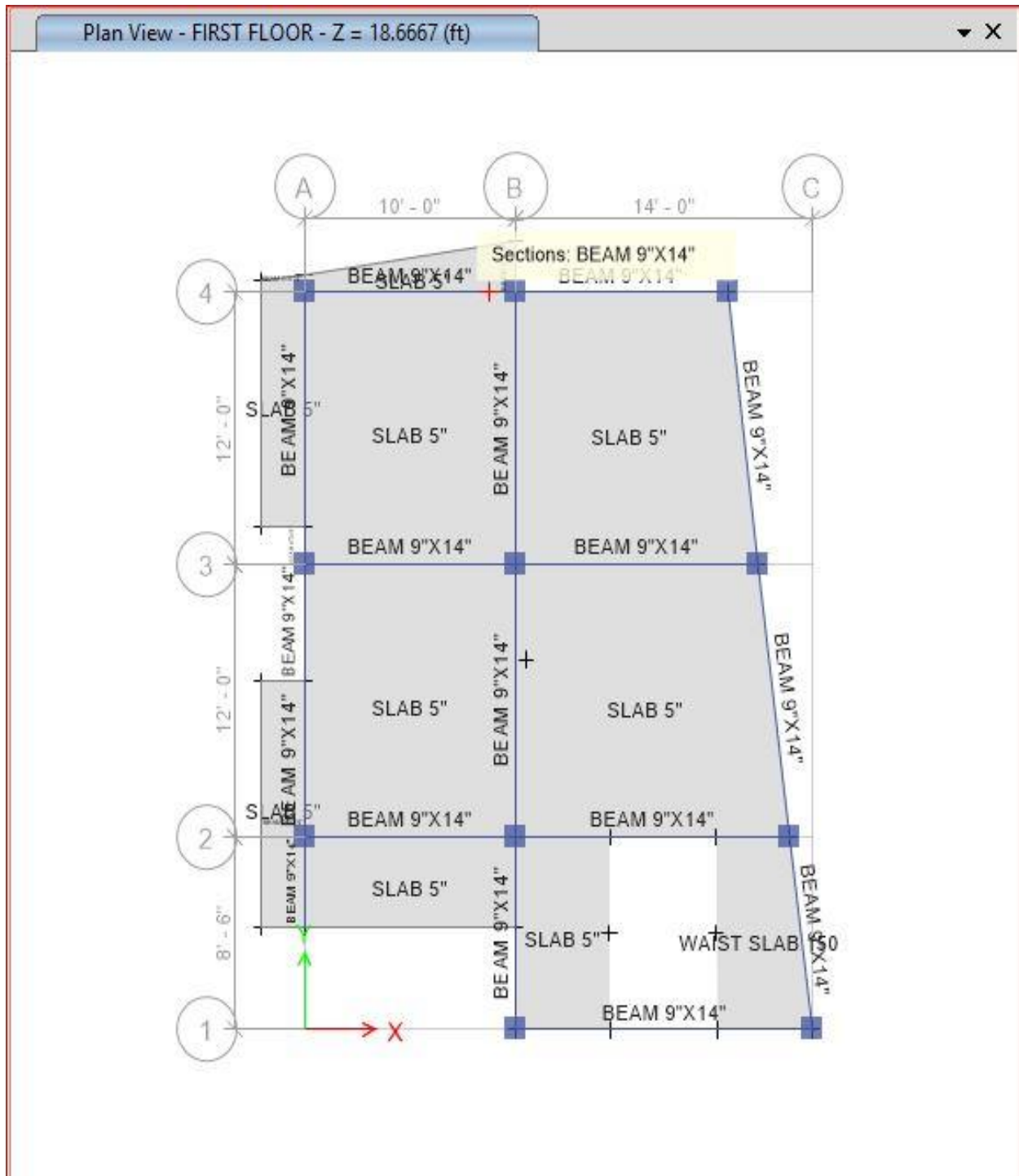
Based on Seismic coefficient method, ETABS utilizes the following procedure to generate the lateral seismic loads.

1. User provides seismic zone co-efficient and desired seismic load command.
2. User provides the structural period " T " = $0.075h^{0.75}$
3. Program calculates S_a/g utilizing T .
4. Program calculates V_b from the above equation. W is obtained from the weight data provided by the user.
5. The total lateral seismic load (base shear) is then distributed by the program among different levels of the structure per the IS:1893(Part 1) - 2002 procedures.

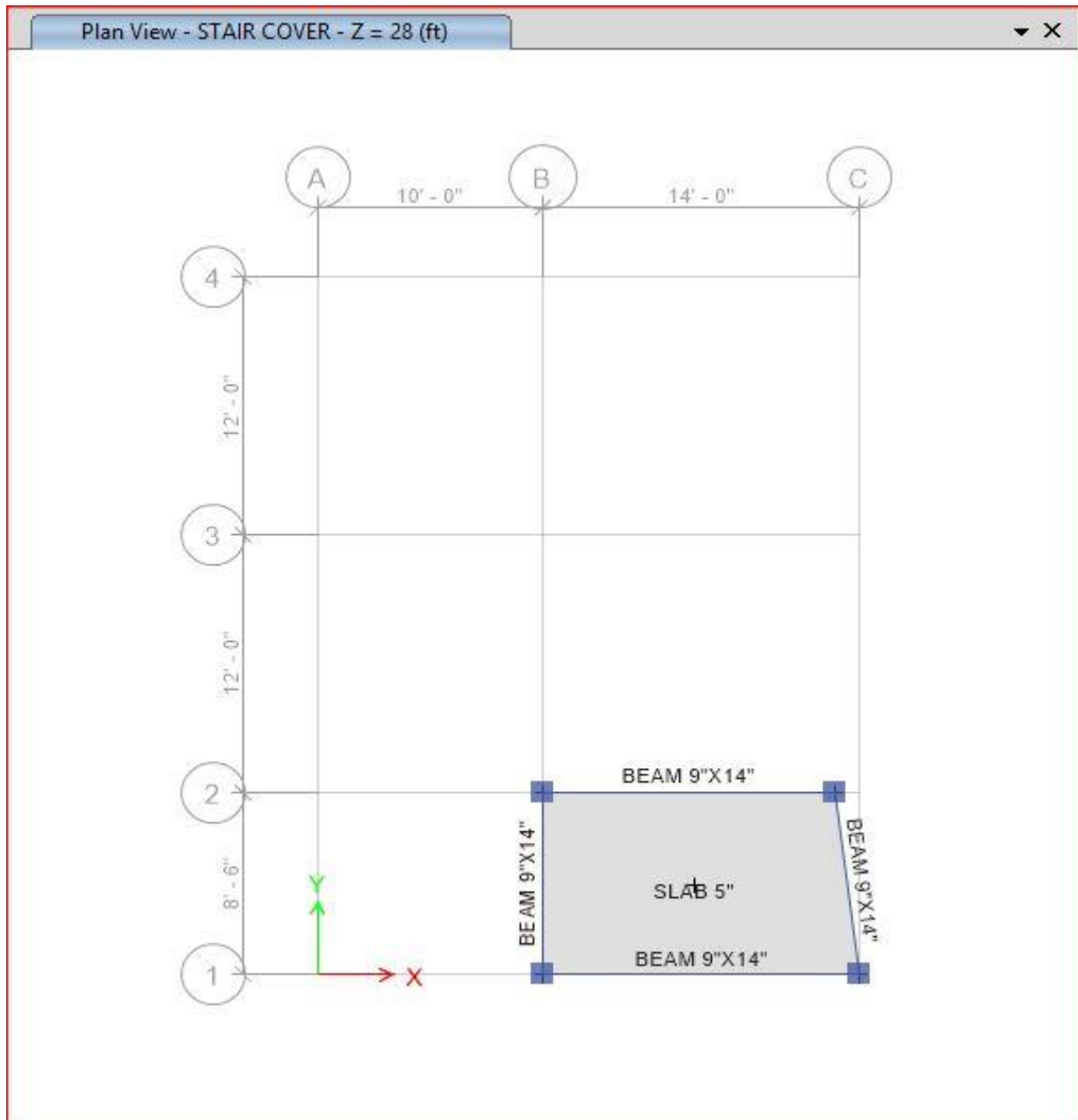
COLUMN AND BEAM LAYOUT PLAN

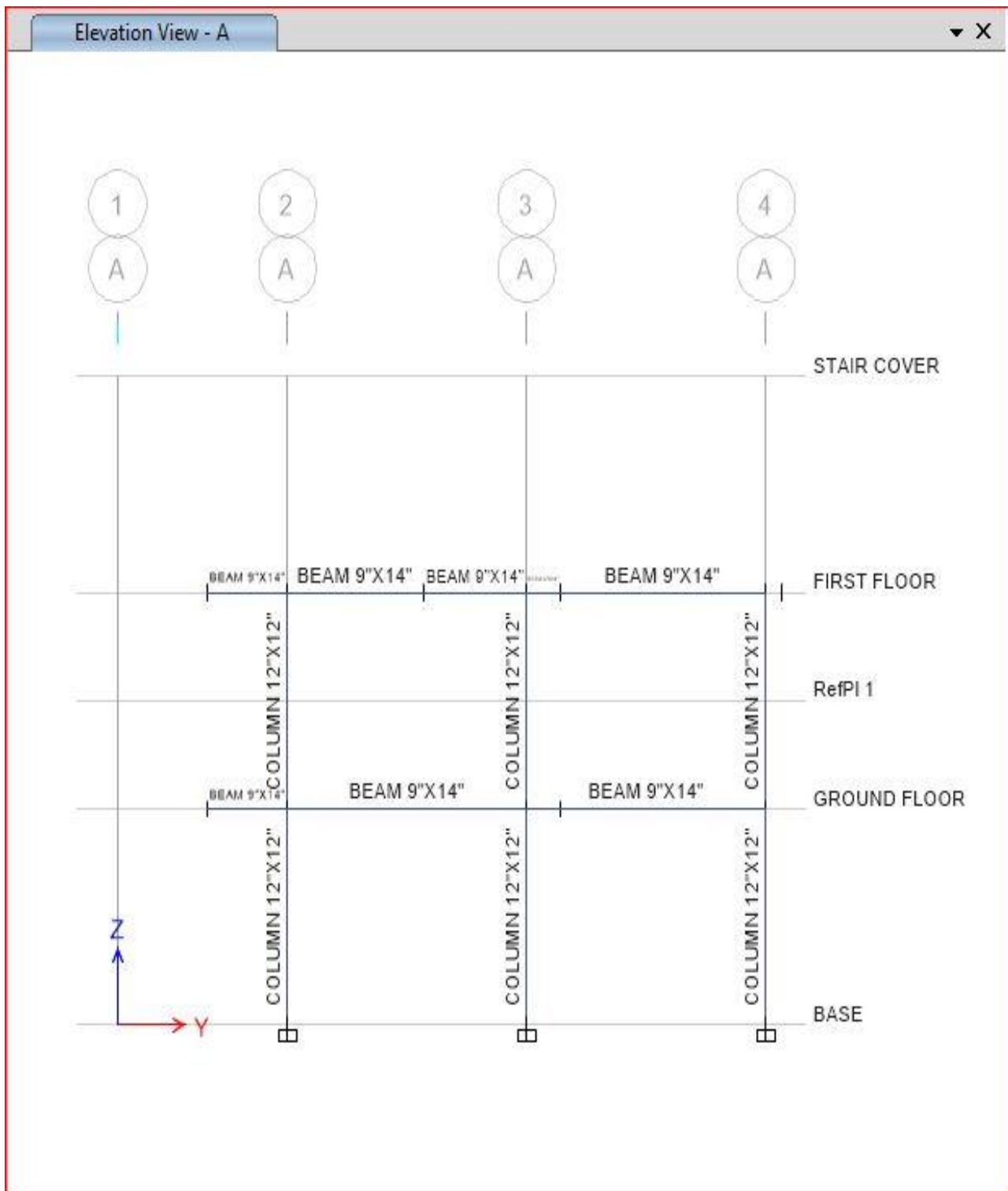


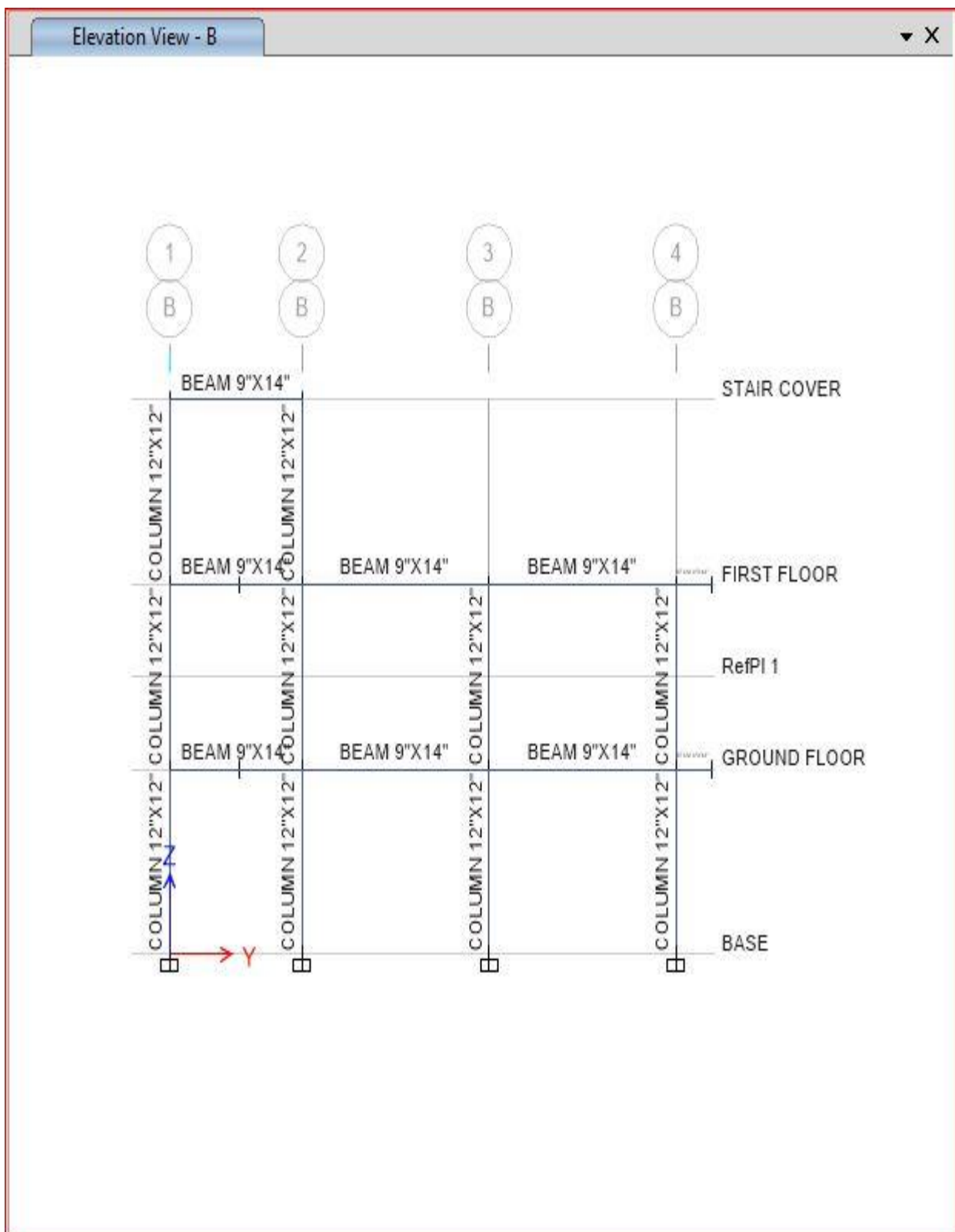
Ground floor



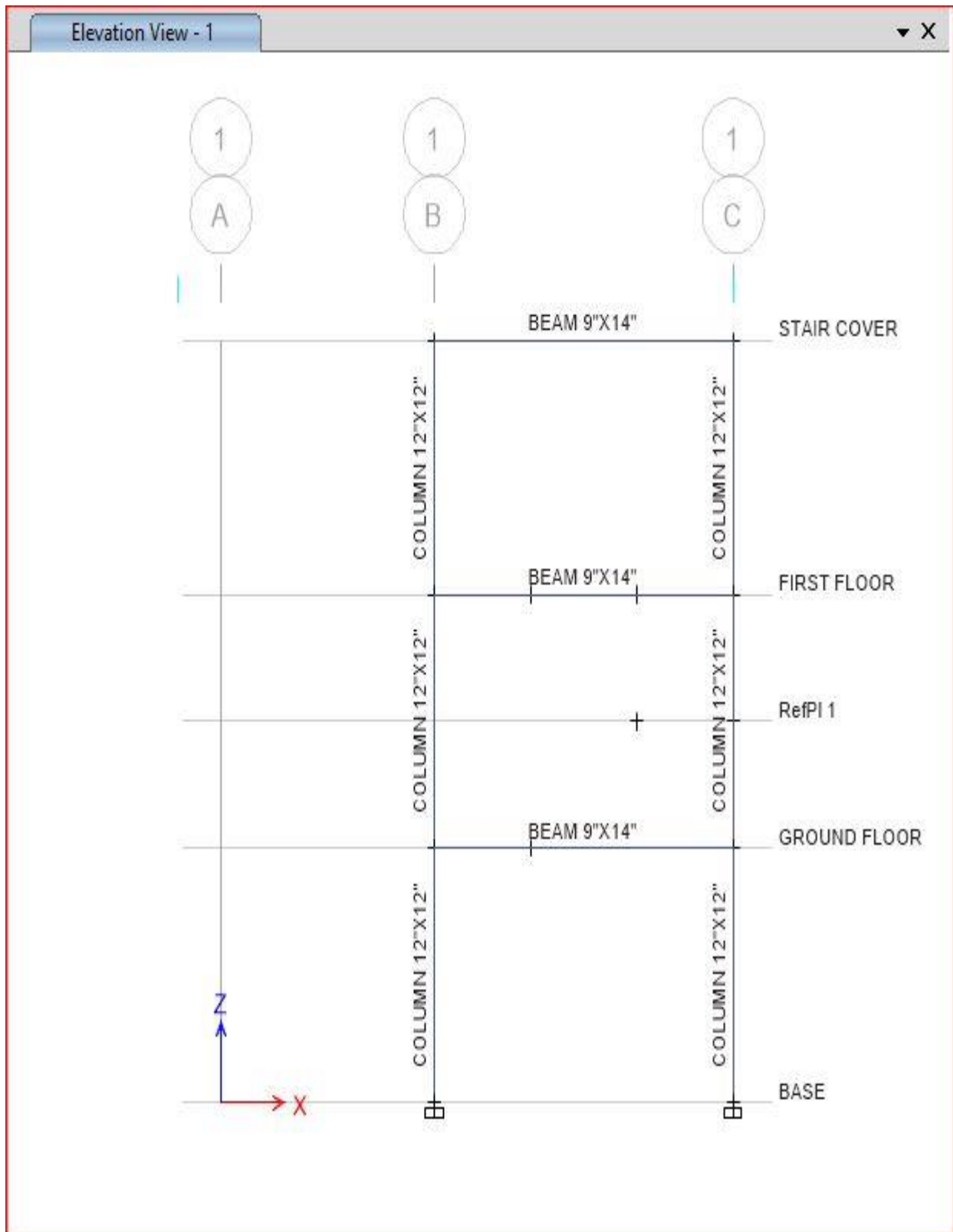
FIRST FLOOR

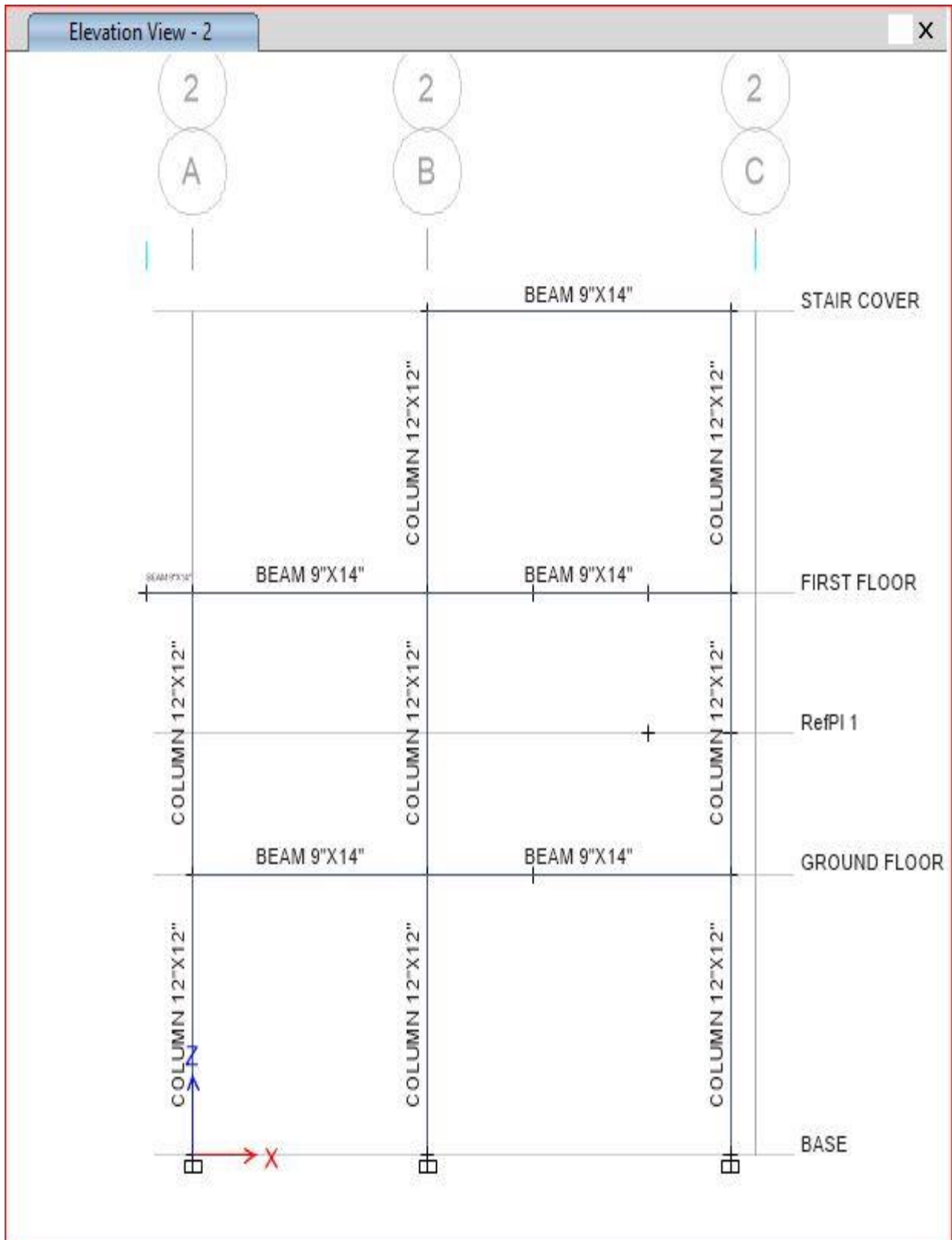
**STAIRCASE COVER FLOOR**

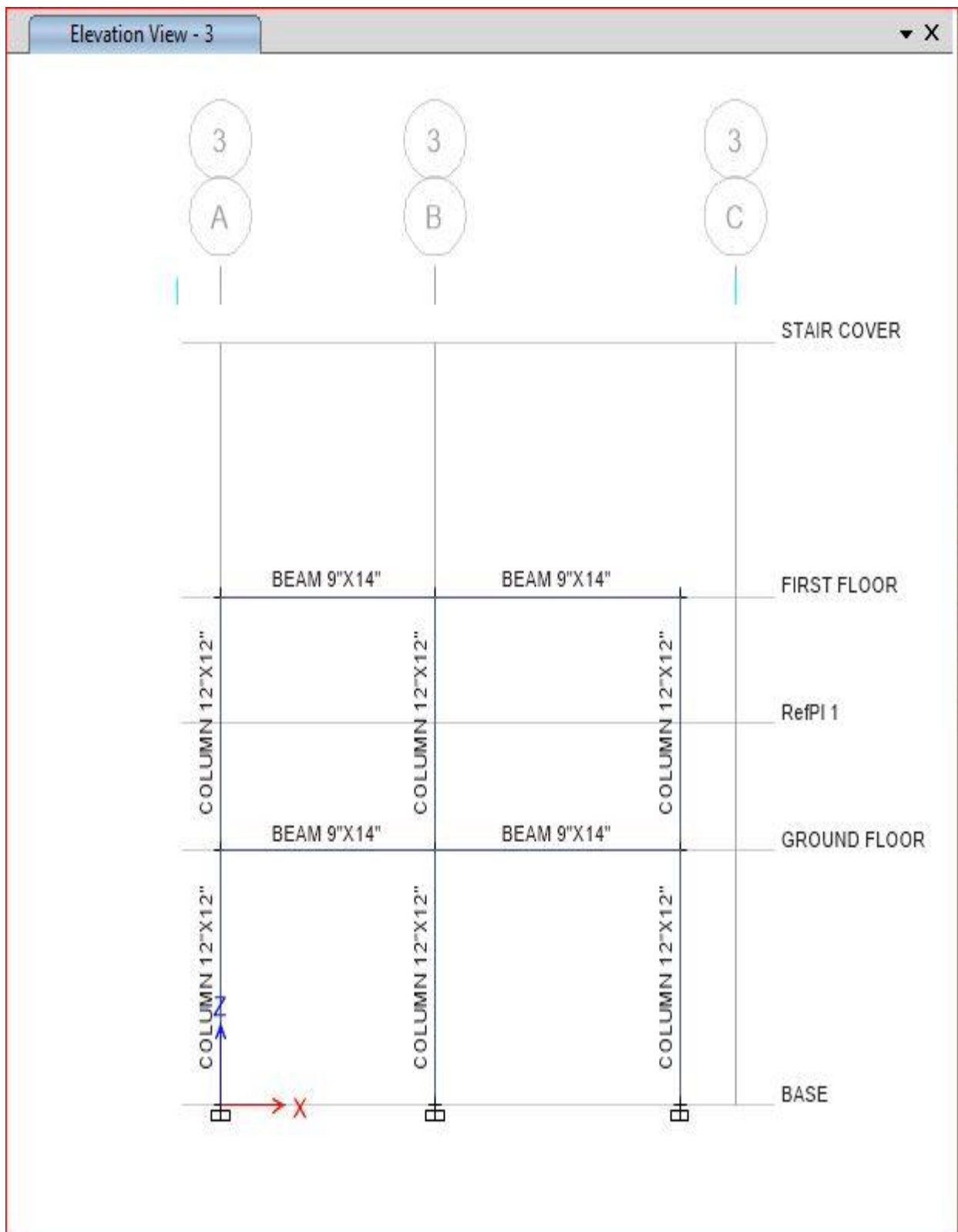
**ELEVATION along-A**

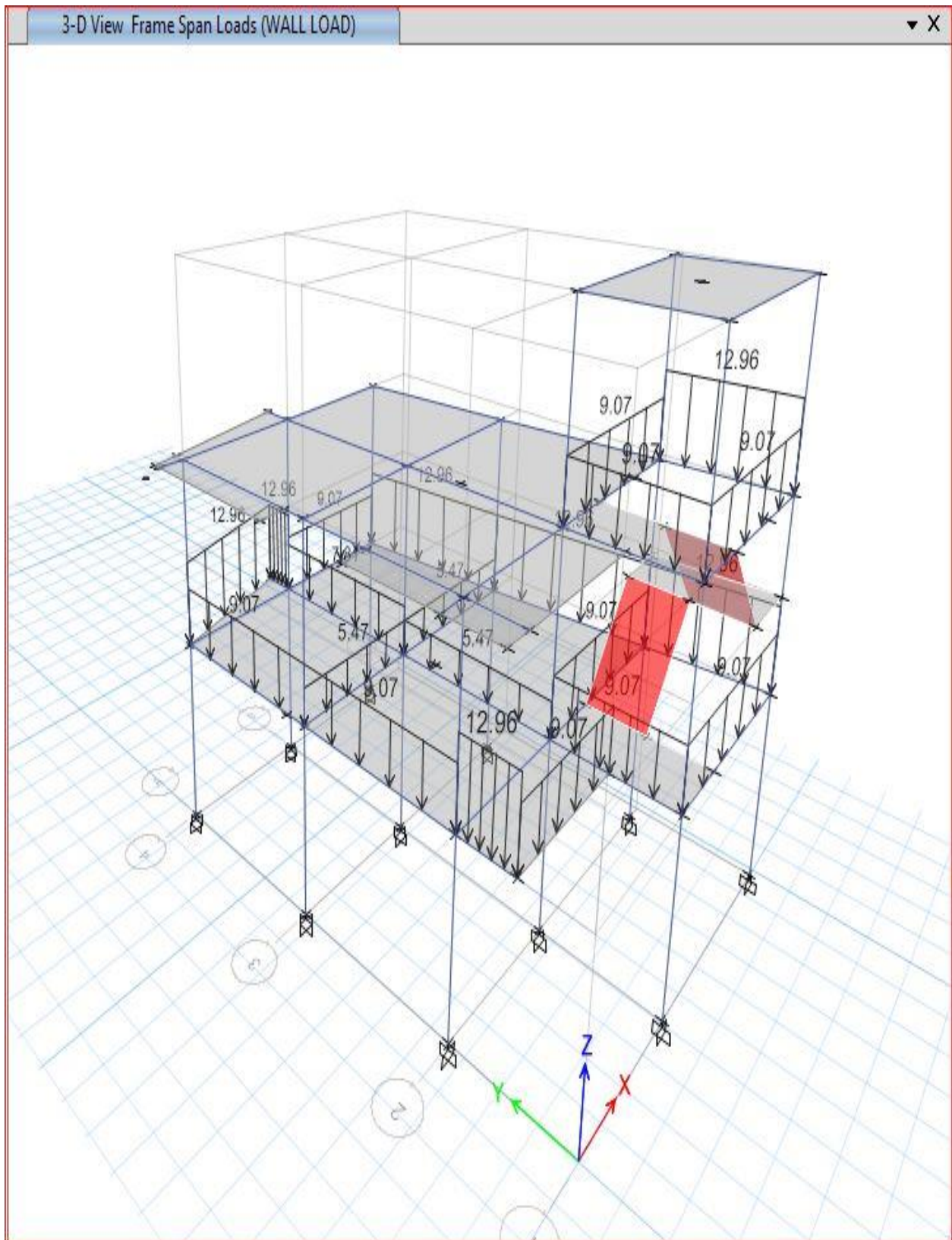


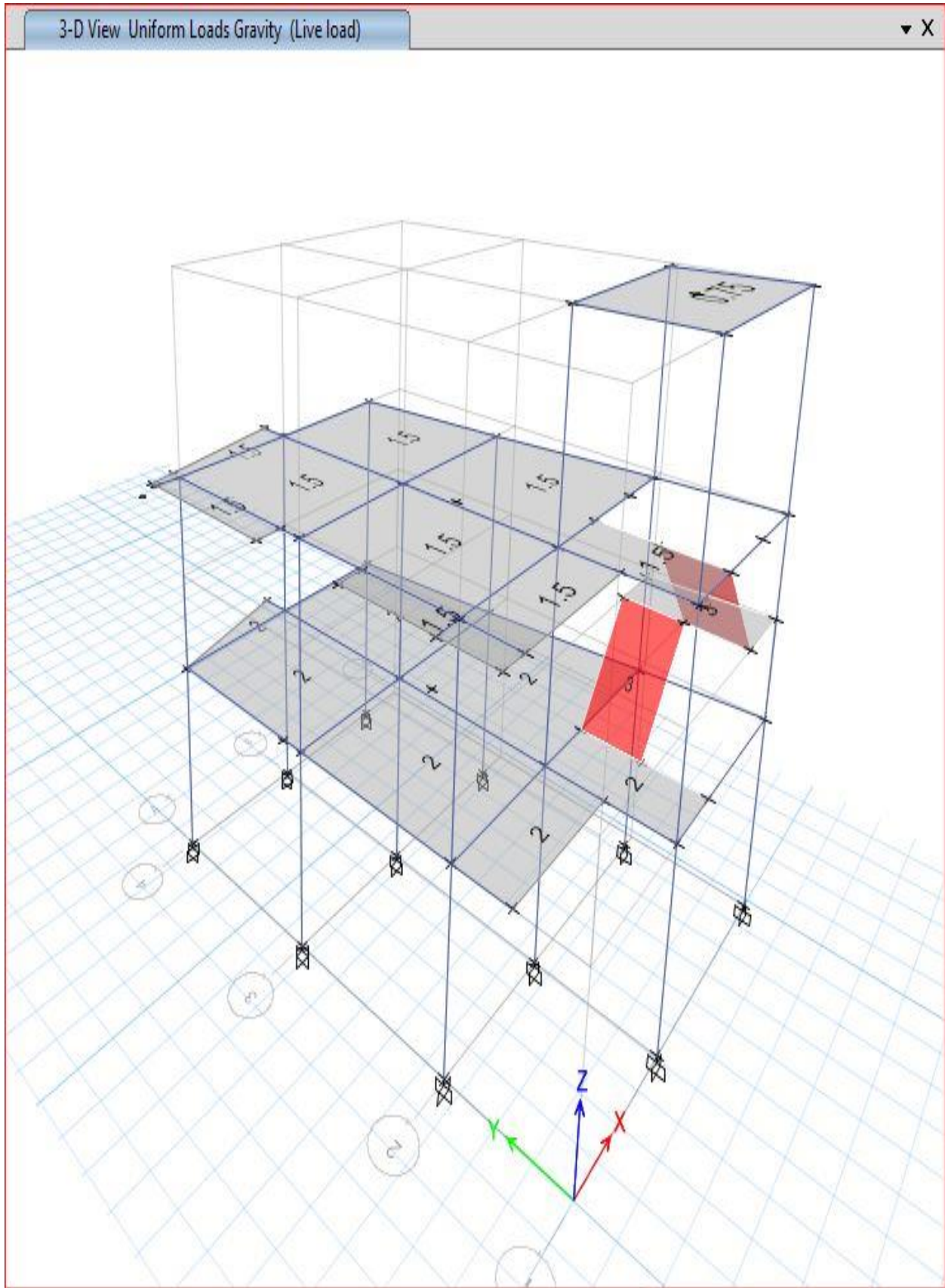
ELEVATION ALONG-B

**ELEVATION ALONG -1**

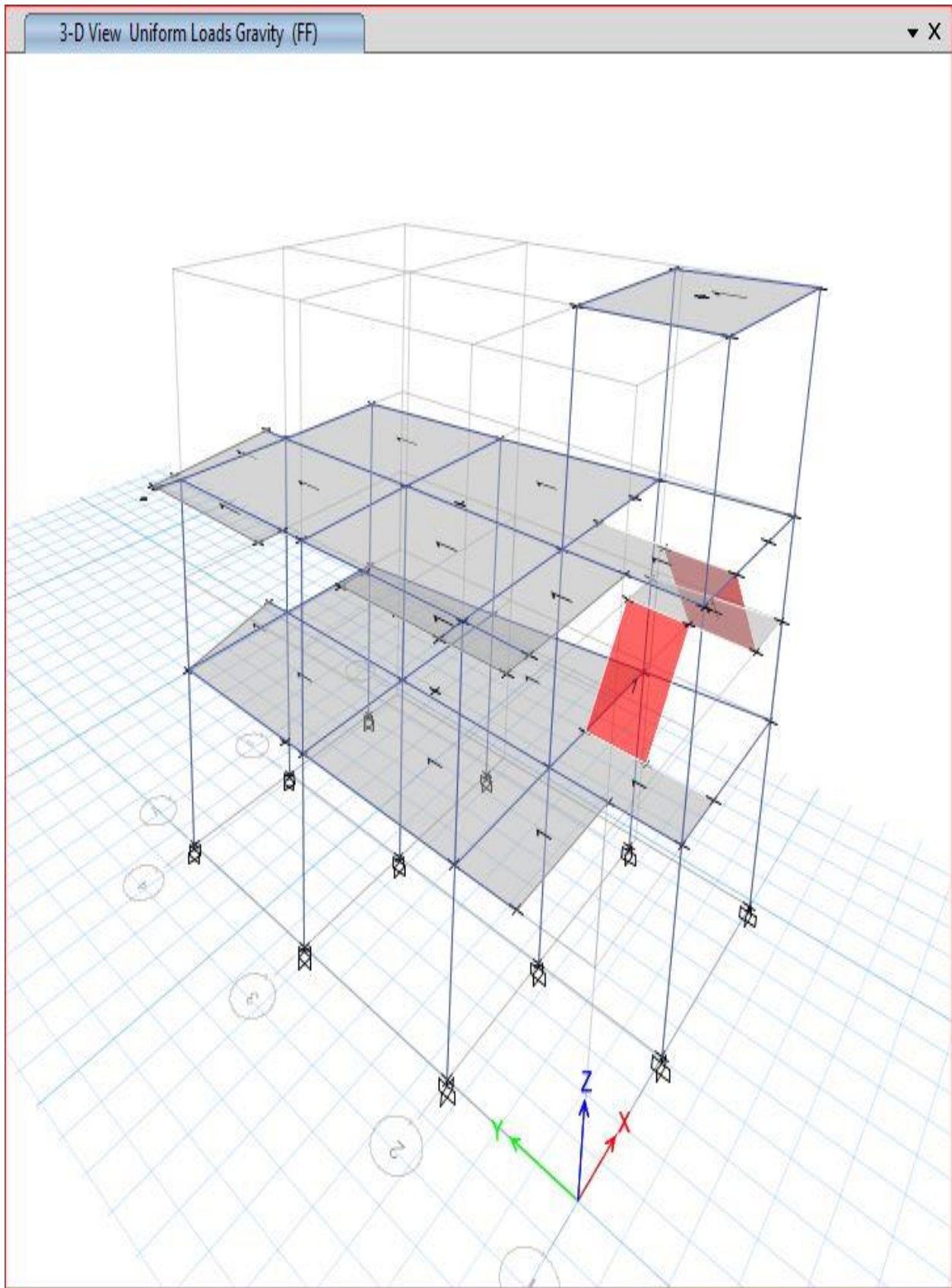
**ELEVATION ALONG-2**

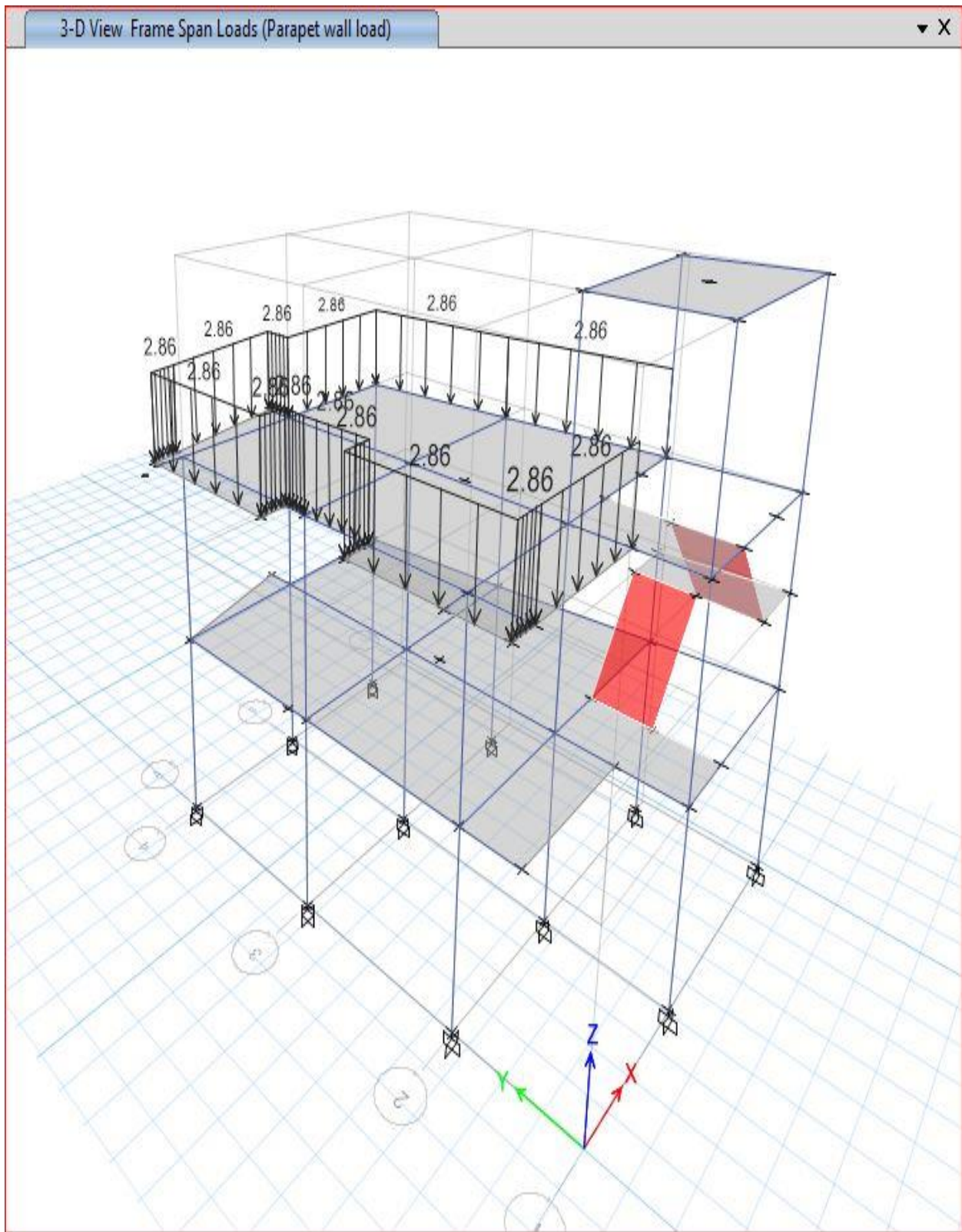
**ELEVATION ALONG-3**





LIVE LOAD $\leq 3 \text{ KN/m}^2$

**FLOOR FINISH**

**PARAPET WALL LOAD**

10. Output:

After all the loading information is provided in the structural model, ETABS analyses the structure and gives the required output (i.e. exact stress, support reactions, displacement, bending moment, shear force, etc.)

Some of the output information as obtained from ETABS after analyzing the structure is shown as below.

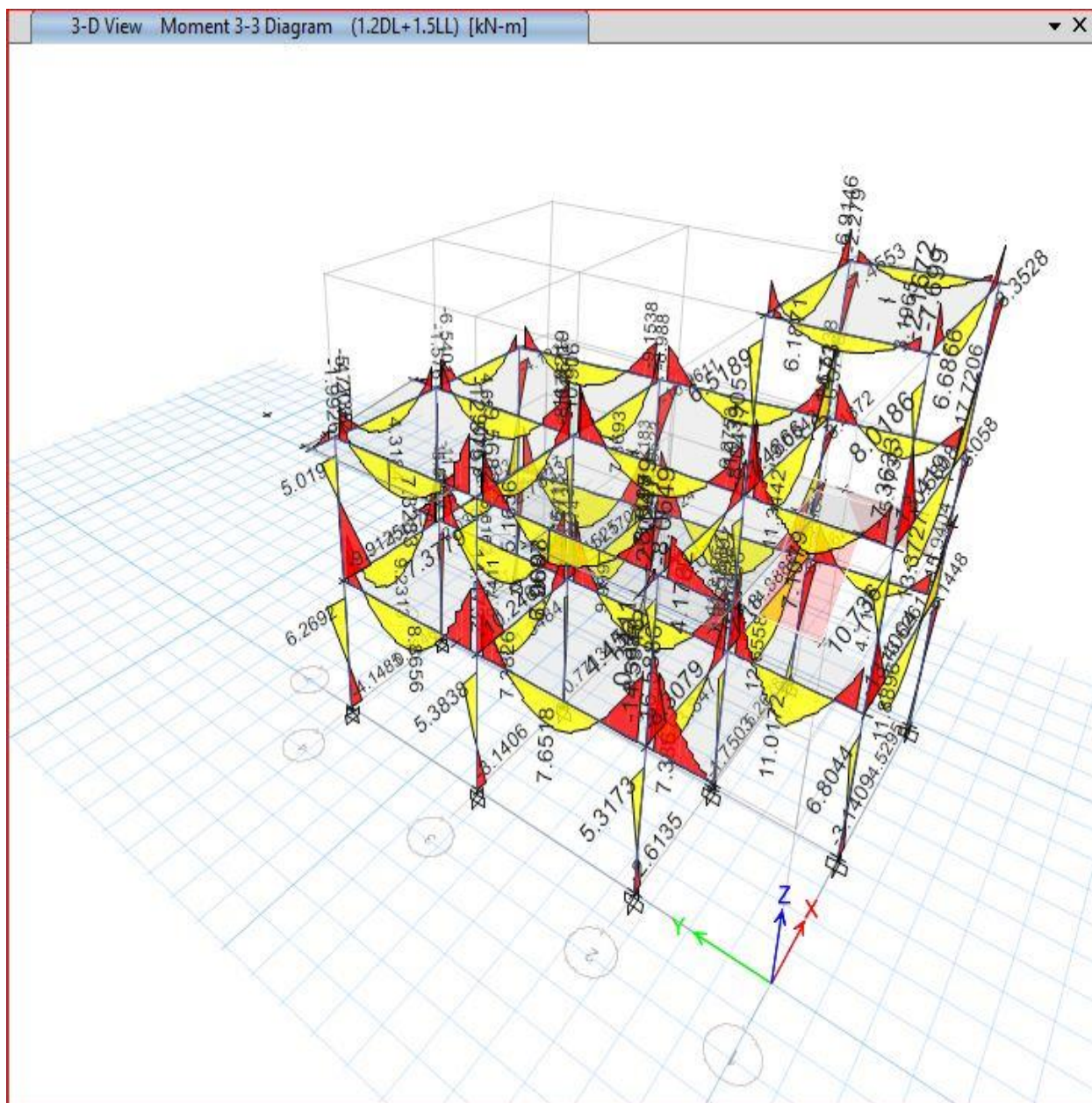


Fig. Bending Moment Diagram of beams and columns (1.2DL+1.5LL)

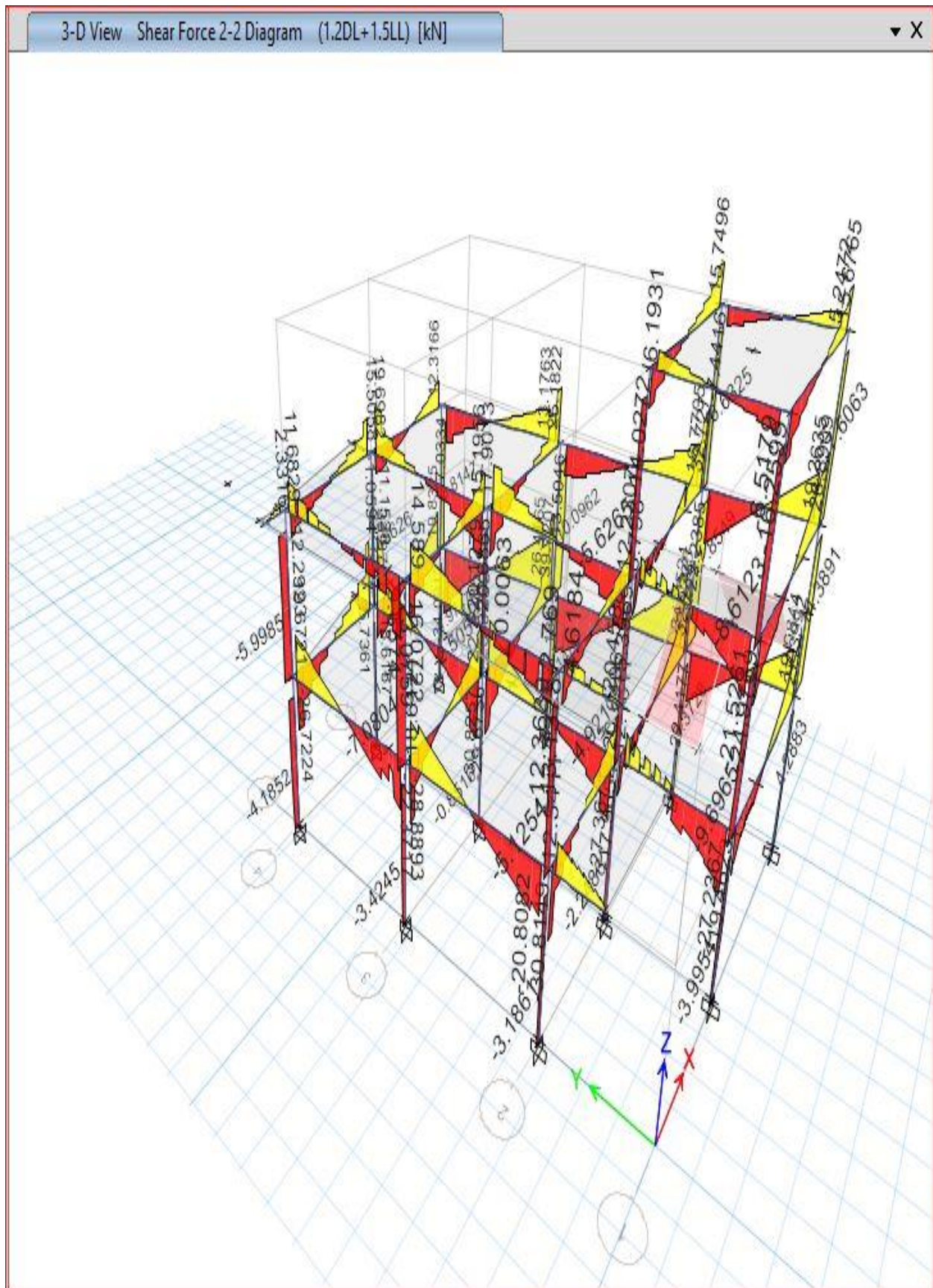


Fig. Shear force Diagram of beams and columns (1.2DL+1.5LL)

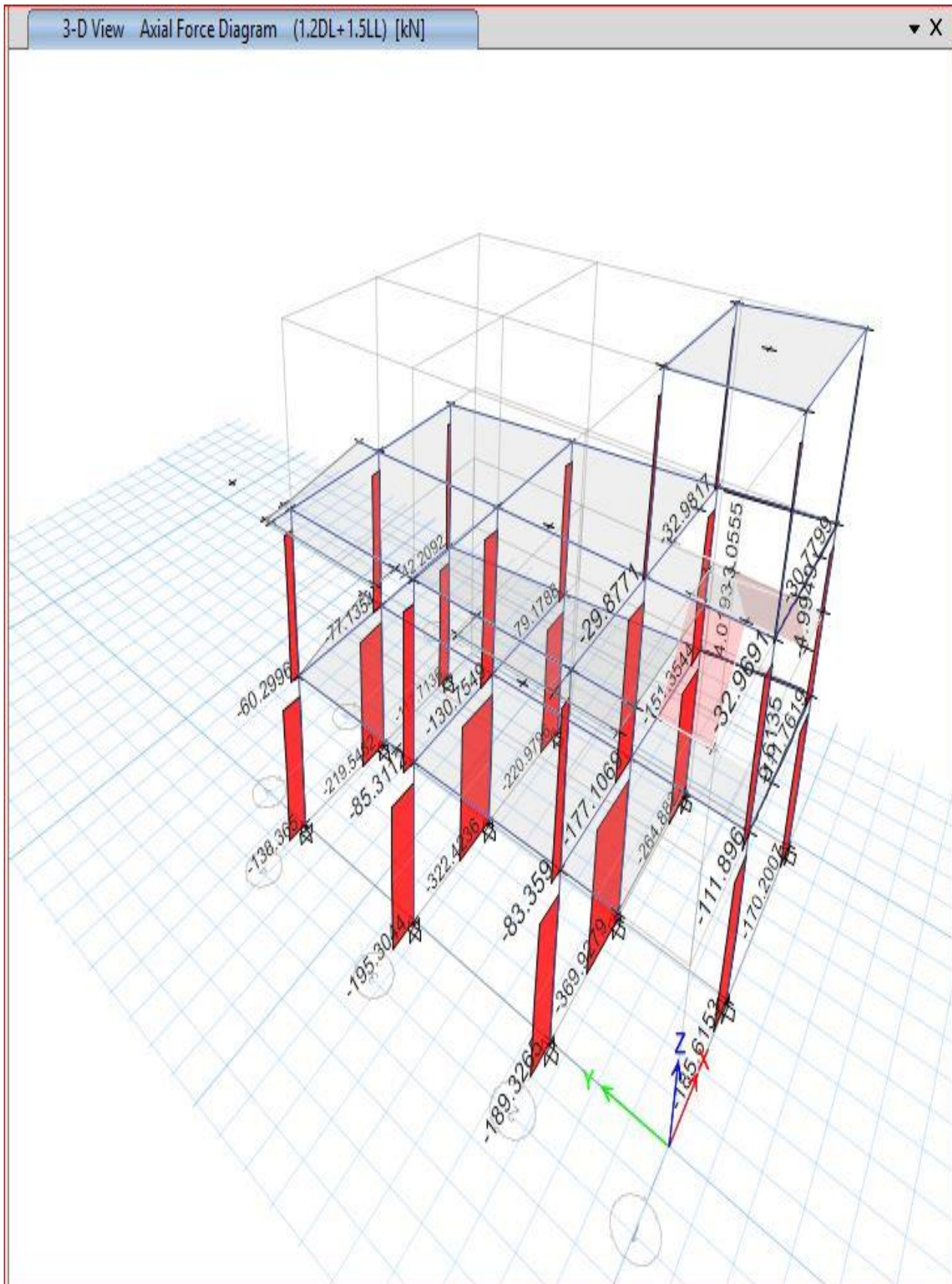


Fig : Axial force diagram of beam and column (1.2(DL+LL))

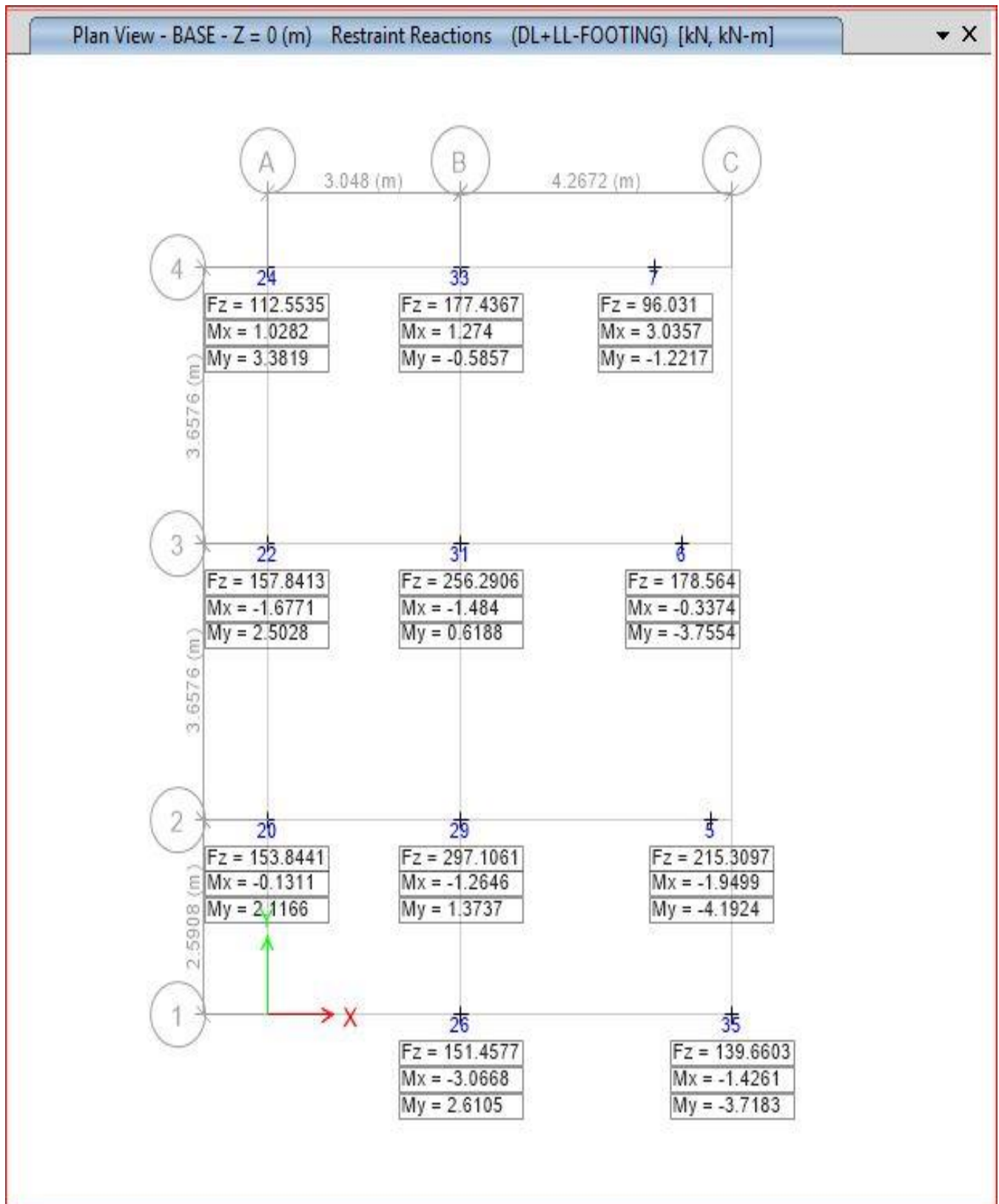


Fig: Base reaction (DL+LL)

JOINT REACTION

Output Case	Case Type	Step Type	Step Number	FX kN	FY kN	FZ kN	MX kN-m	MY kN-m	MZ kN-m	X m	Y m	Z m
1.2DL+1.5LL	Combination			0	5.186E-06	2394.2848	11454.985	-8601.7898	1.835E-05	0	0	0
DL+0.3LL+EQx_uls+0....	Combination	Max		-227.1712	-68.1514	1770.4967	8745.034	-7512.3979	918.1646	0	0	0
DL+0.3LL+EQx_uls+0....	Combination	Min		-227.1712	-68.1514	1770.4967	8745.034	-7512.3979	597.6227	0	0	0
DL+0.3LL-EQx_uls-0....	Combination	Max		227.1712	68.1514	1770.4967	8079.1682	-5292.846	-597.6227	0	0	0
DL+0.3LL-EQx_uls-0....	Combination	Min		227.1712	68.1514	1770.4967	8079.1682	-5292.846	-918.1645	0	0	0
DL+0.3LL+EQx_uls-0....	Combination	Max		-227.1712	68.1514	1770.4967	8079.1682	-7512.3979	1511.8242	0	0	0
DL+0.3LL+EQx_uls-0....	Combination	Min		-227.1712	68.1514	1770.4967	8079.1682	-7512.3979	1014.9274	0	0	0
DL+0.3LL-EQx_uls+0....	Combination	Max		227.1712	-68.1514	1770.4967	8745.034	-5292.846	-1014.9273	0	0	0
DL+0.3LL-EQx_uls+0....	Combination	Min		227.1712	-68.1514	1770.4967	8745.034	-5292.846	-1511.8242	0	0	0
DL+0.3LL+0.3EQx_uls...	Combination	Max		-68.1514	-227.1713	1770.4967	9521.8775	-6735.5547	-453.6253	0	0	0
DL+0.3LL+0.3EQx_uls...	Combination	Min		-68.1514	-227.1713	1770.4967	9521.8775	-6735.5548	-624.9345	0	0	0
DL+0.3LL+0.3EQx_uls...	Combination	Max		-68.1514	227.1713	1770.4967	7302.3248	-6735.5547	1353.9311	0	0	0
DL+0.3LL+0.3EQx_uls...	Combination	Min		-68.1514	227.1713	1770.4967	7302.3248	-6735.5548	937.3903	0	0	0
DL+0.3LL-0.3EQx_uls...	Combination	Max		68.1514	227.1713	1770.4967	7302.3248	-6069.6892	624.9345	0	0	0
DL+0.3LL-0.3EQx_uls...	Combination	Min		68.1514	227.1713	1770.4967	7302.3248	-6069.6892	453.6253	0	0	0
DL+0.3LL-0.3EQx_uls...	Combination	Max		68.1514	-227.1713	1770.4967	9521.8775	-6069.6892	-937.3903	0	0	0
DL+0.3LL-0.3EQx_uls...	Combination	Min		68.1514	-227.1713	1770.4967	9521.8775	-6069.6892	-1353.9311	0	0	0
DL+0.3LL+0.3EQx_sls...	Combination	Max		-65.5502	-218.5006	1770.4967	9479.5196	-6722.8474	-436.3113	0	0	0
DL+0.3LL+0.3EQx_sls...	Combination	Min		-65.5502	-218.5007	1770.4967	9479.5196	-6722.8474	-601.082	0	0	0
DL+0.3LL-0.3EQx_sls...	Combination	Max		65.5502	-218.5006	1770.4967	9479.5196	-6082.3965	-901.612	0	0	0
DL+0.3LL-0.3EQx_sls...	Combination	Min		65.5502	-218.5007	1770.4967	9479.5196	-6082.3965	-1302.2543	0	0	0
DL+0.3LL-0.3EQx_sls...	Combination	Max		65.5502	218.5007	1770.4967	7344.6826	-6082.3965	601.082	0	0	0
DL+0.3LL-0.3EQx_sls...	Combination	Min		65.5502	218.5007	1770.4967	7344.6826	-6082.3965	436.3114	0	0	0
DL+0.3LL+0.3EQx_sls...	Combination	Max		-65.5502	218.5007	1770.4967	7344.6826	-6722.8474	1302.2544	0	0	0
DL+0.3LL+0.3EQx_sls...	Combination	Min		-65.5502	218.5007	1770.4967	7344.6826	-6722.8474	901.6121	0	0	0

Modal Mass Participating Ratios

TABLE: Modal Participating Mass Ratios														
Case	Mode	Period	UX	UY	UZ	SumUX	SumUY	SumUZ	RX	RY	RZ	SumRX	SumRY	SumRZ
		sec												
Modal	1	0.502	0.7508	0.0017	0	0.7508	0.0017	0	0.000001309	0.1377	0.1749	0.000001309	0.1377	0.1749
Modal	2	0.486	0.009	0.9004	0	0.7598	0.9022	0	0.1028	0.0001	0.0084	0.1028	0.1378	0.1834
Modal	3	0.437	0.1612	0.0179	0	0.921	0.9201	0	0.0074	0.001	0.7315	0.1102	0.1387	0.9367
Modal	4	0.188	0.0418	0.0035	0	0.9629	0.9235	0	0.03	0.5713	0.0096	0.1403	0.71	0.9245
Modal	5	0.185	0.0006	0.0531	0	0.9634	0.9766	0	0.6989	0.0112	0.0021	0.8392	0.7213	0.9265
Modal	6	0.159	0.025	0.0059	0	0.9884	0.9825	0	0.0288	0.1765	0.0583	0.868	0.8977	0.9848
Modal	7	0.133	0.006	0.0152	0	0.9944	0.9977	0	0.1085	0.0457	0.0001	0.9765	0.9435	0.9849
Modal	8	0.125	0.0032	0.001	0	0.9976	0.9988	0	0.0082	0.0288	0.0013	0.9846	0.9723	0.9862
Modal	9	0.113	0.0024	0.0012	0	1	1	0	0.0148	0.0275	0.0137	0.9994	0.9998	1
Modal	10	0.031	0	0	0	1	1	0	0.000002946	0	0	0.9994	0.9998	1
Modal	11	0.024	5.176E-07	0.00002353	0	1	1	0	0.0002	0.0001	0.00002146	0.9996	0.9999	1
Modal	12	0.021	0.00001364	0	0	1	1	0	0.0002	0.0000271	0.000008993	0.9998	0.9999	1

MODAL PERIODS AND FREQUENCY:

TABLE: Modal Periods And Frequencies					
Case	Mode	Period	Frequency	CircFreq	Eigenvalue
		sec	cyc/sec	rad/sec	rad ² /sec ²
Modal	1	0.502	1.994	12.5259	156.8983
Modal	2	0.486	2.056	12.9202	166.9323
Modal	3	0.437	2.29	14.3861	206.9605
Modal	4	0.188	5.305	33.3339	1111.1475
Modal	5	0.185	5.41	33.9952	1155.6712
Modal	6	0.159	6.298	39.5735	1566.0598
Modal	7	0.133	7.539	47.371	2244.0079
Modal	8	0.125	7.973	50.098	2509.8057
Modal	9	0.113	8.857	55.6501	3096.9281
Modal	10	0.031	32.383	203.4666	41398.6615
Modal	11	0.024	41.759	262.3817	68844.1682
Modal	12	0.021	46.901	294.6881	86841.0584

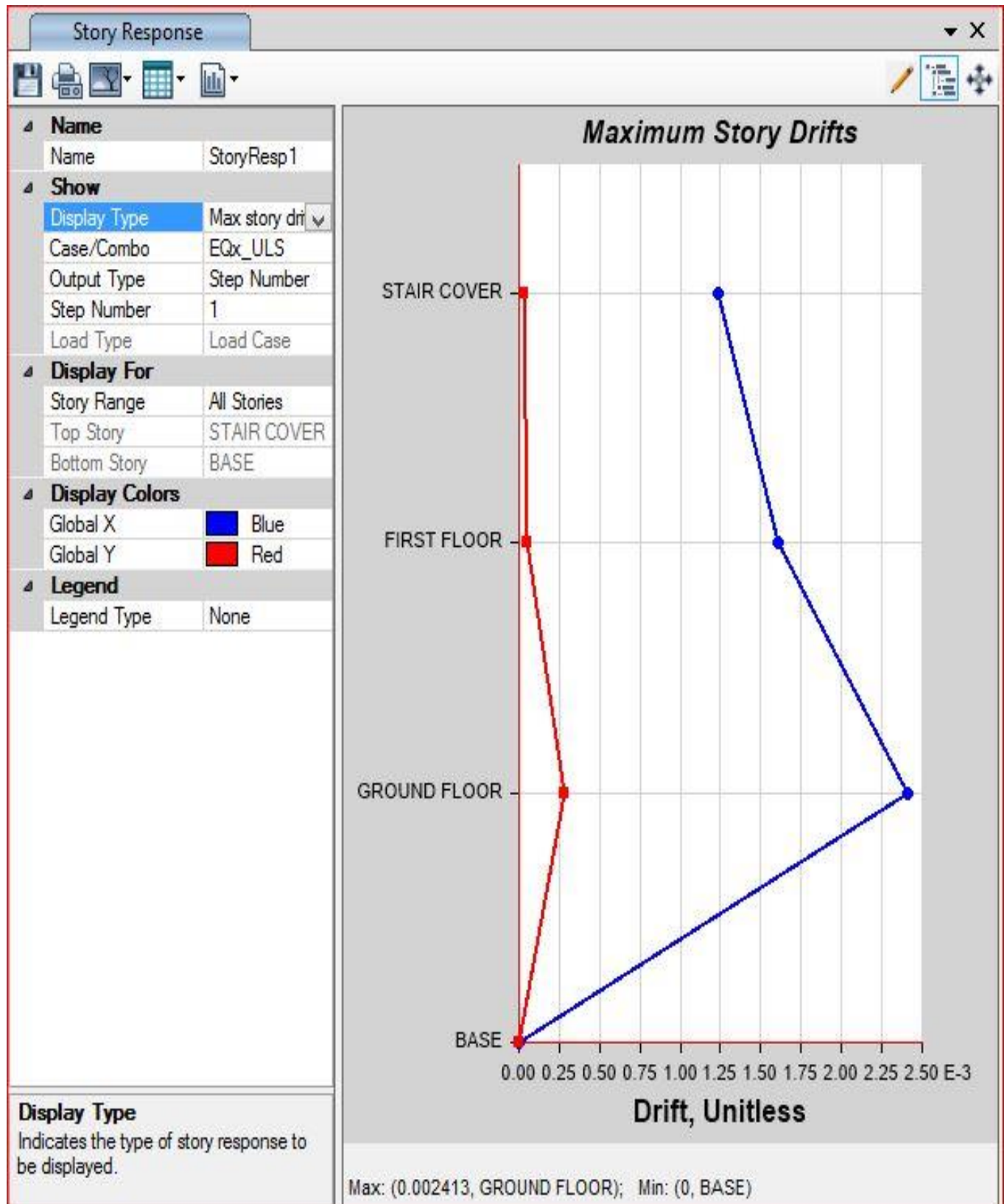
CENTER OF MASS AND STIFFNESS :

Story	Diaphragm	Mass X	Mass Y	XCM	YCM	Cum Mass X	Cum Mass Y	XCCM	YCCM	XCR	YCR	Δx	Δy	x-length	y-length	% eccentricity in		check	check
		kg	kg	m	m	kg	kg	m	m	m	m					x-direction	in y-direction		
GROUND FLOOR	D1	91581.45	91581.45	3.291	5.494	91581.45	91581.45	3.291	5.494	3.586	5.168	-0.2949	0.3255	7.315	9.906	-4.03	3.29	ok	ok
FIRST FLOOR	D2	100381.8	100381.8	3.162	5.523	100381.8	100381.8	3.162	5.523	3.982	4.574	-0.8202	0.9495	7.315	9.906	-5.68	9.59	ok	ok
STAIR COVER	D3	8639.41	8639.41	5.101	1.276	8639.41	8639.41	5.101	1.276	4.815	2.075	0.286	-0.799	7.315	9.906	3.91	-8.07	ok	ok

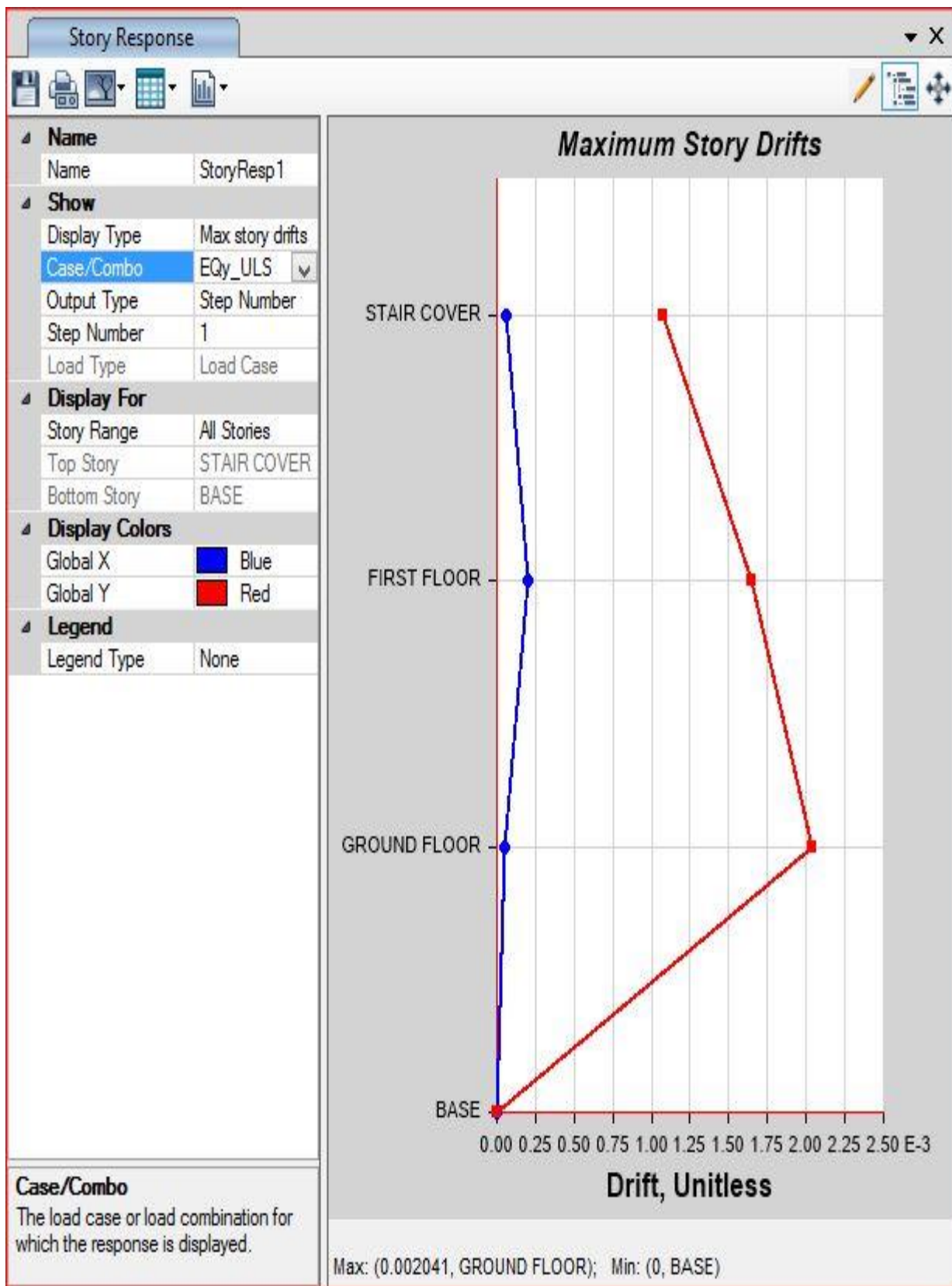
Mass Source :

Name	Is Default	Include Lateral Mass?	Include Vertical Mass?	Lump Mass?	Source Self Mass?	Source Added Mass?	Source Load Patterns?	Move Mass Centroid?	Load Pattern	Multiplier	GUID
MsSrc	Yes	Yes	No	Yes	No	Yes	Yes	No	Dead	1	4db263a9-da...
MsSrc									Live load	0.3	
MsSrc									WALL LOAD	1	
MsSrc									Partition Load	1	
MsSrc									Parapet wall l...	1	
MsSrc									FF	1	

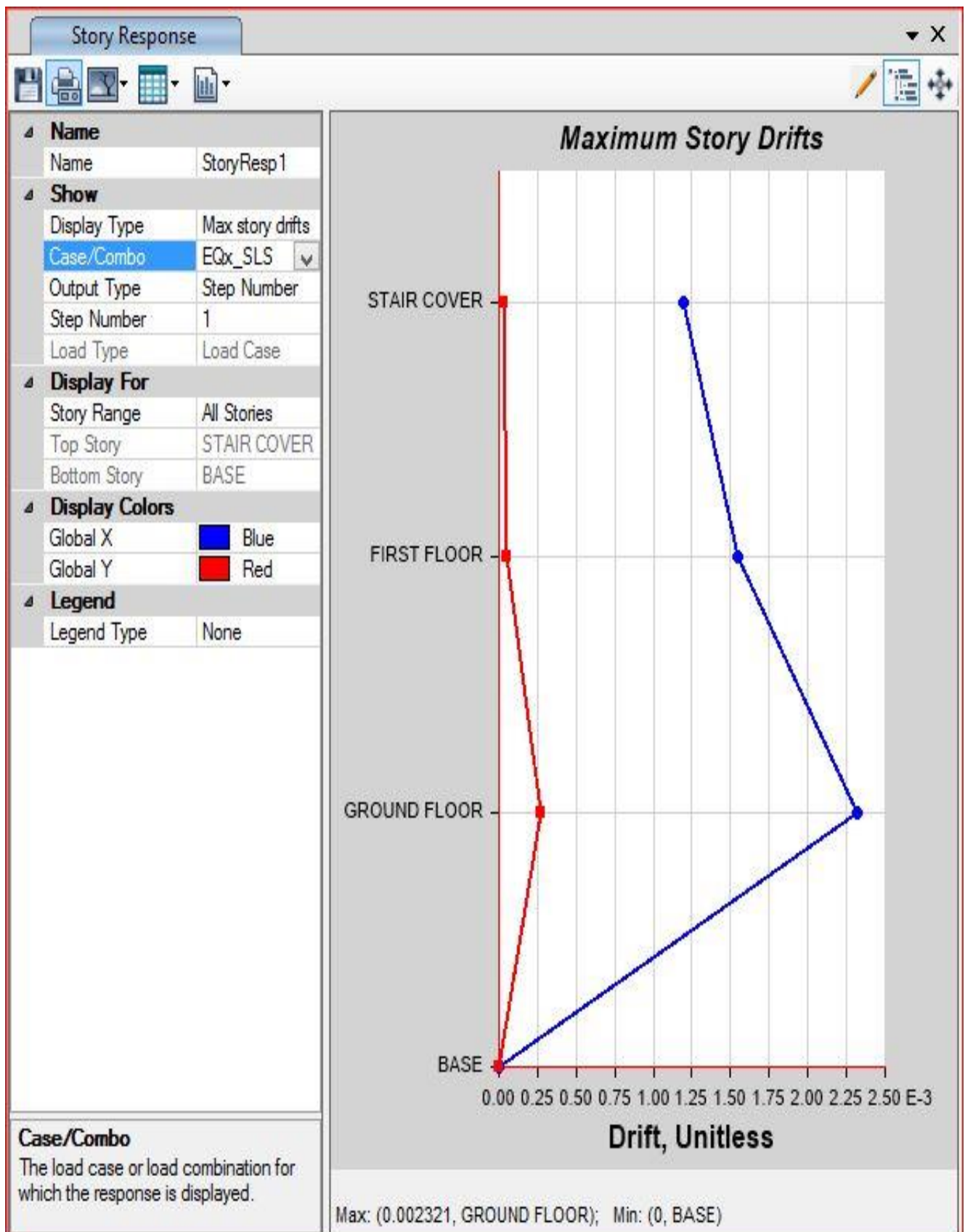
Story Response - Maximum Story Drift



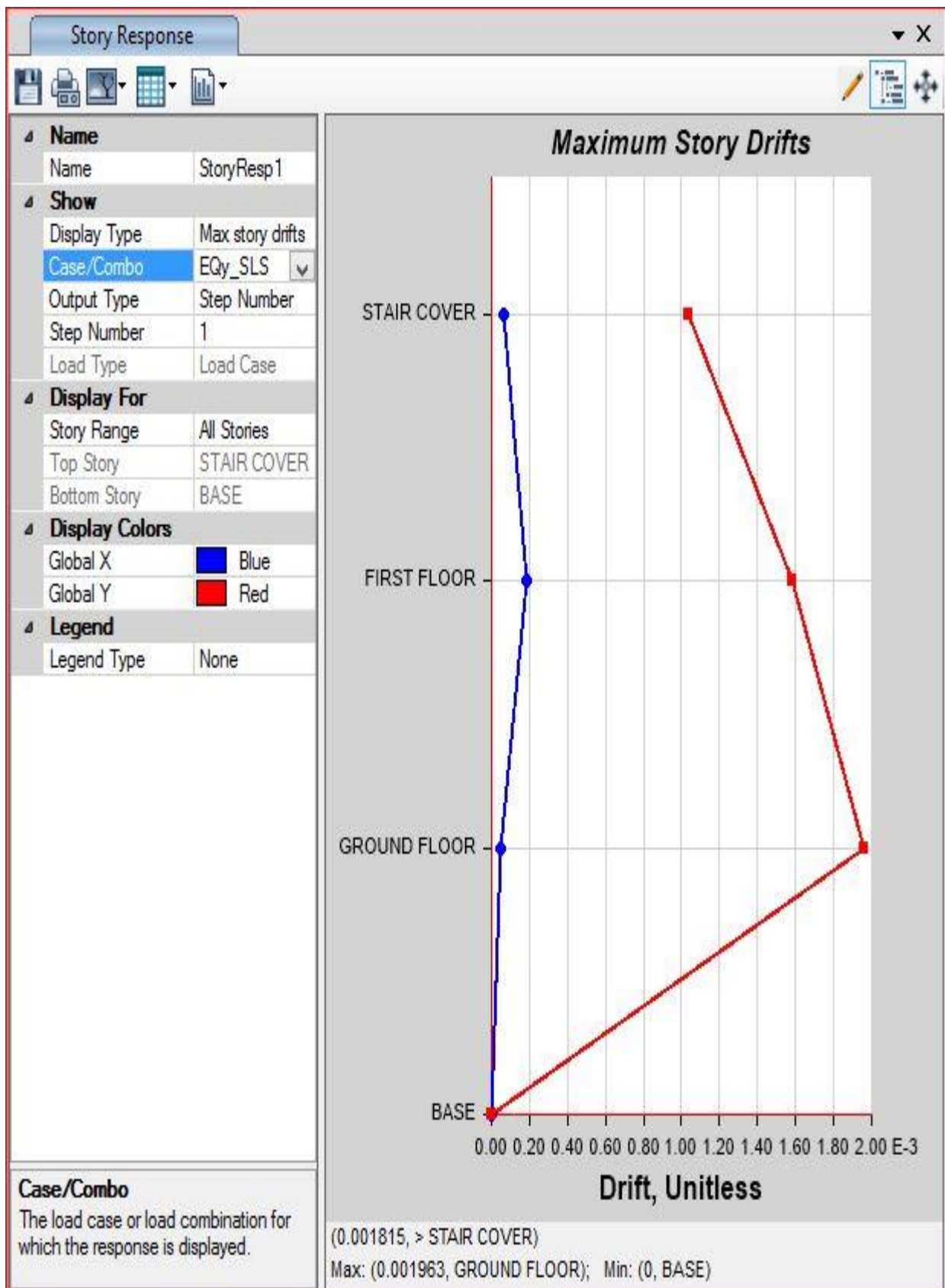
EQx_ULS



EQy_ULS

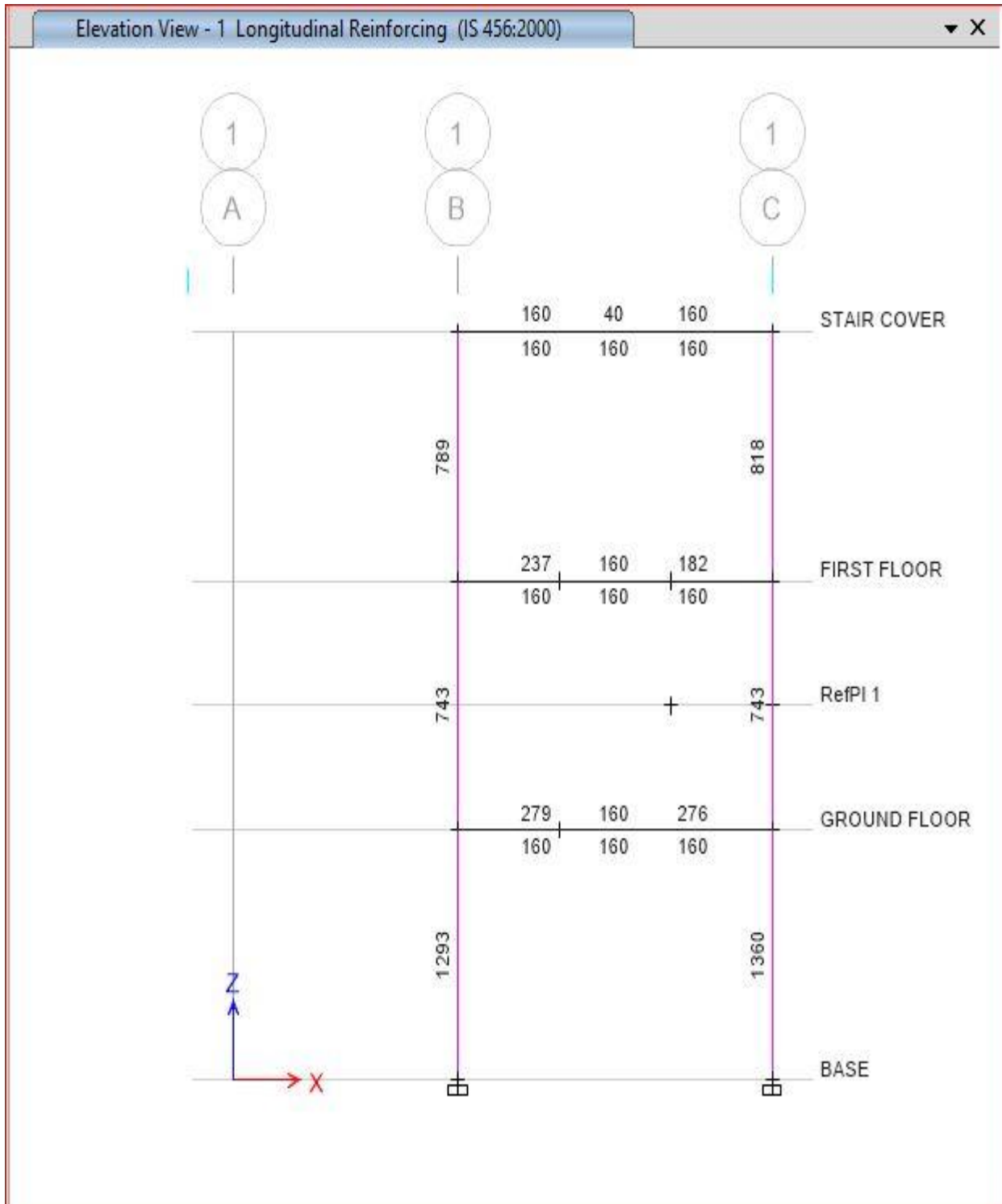


EQx_SLS

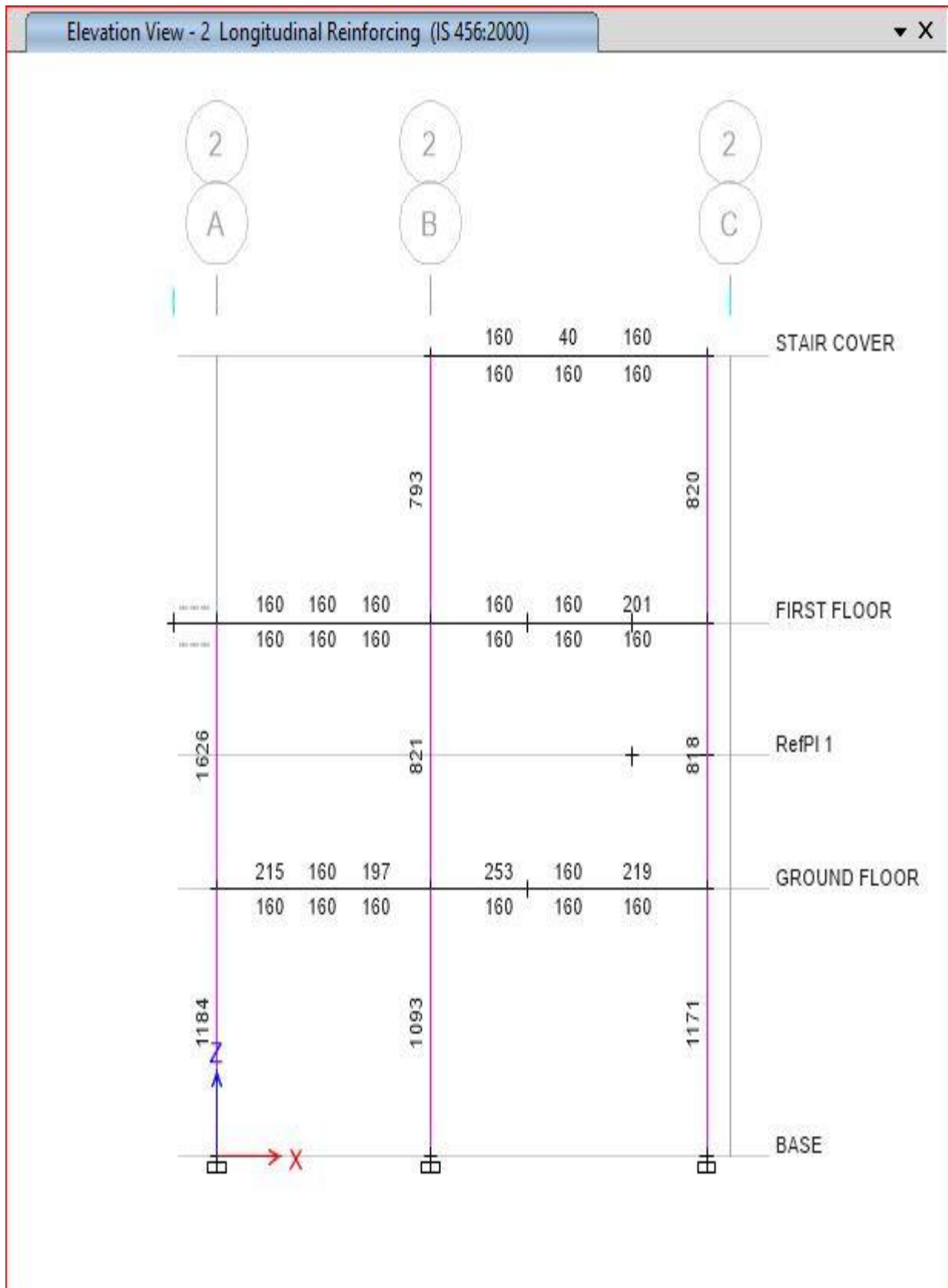


EQy_SLS

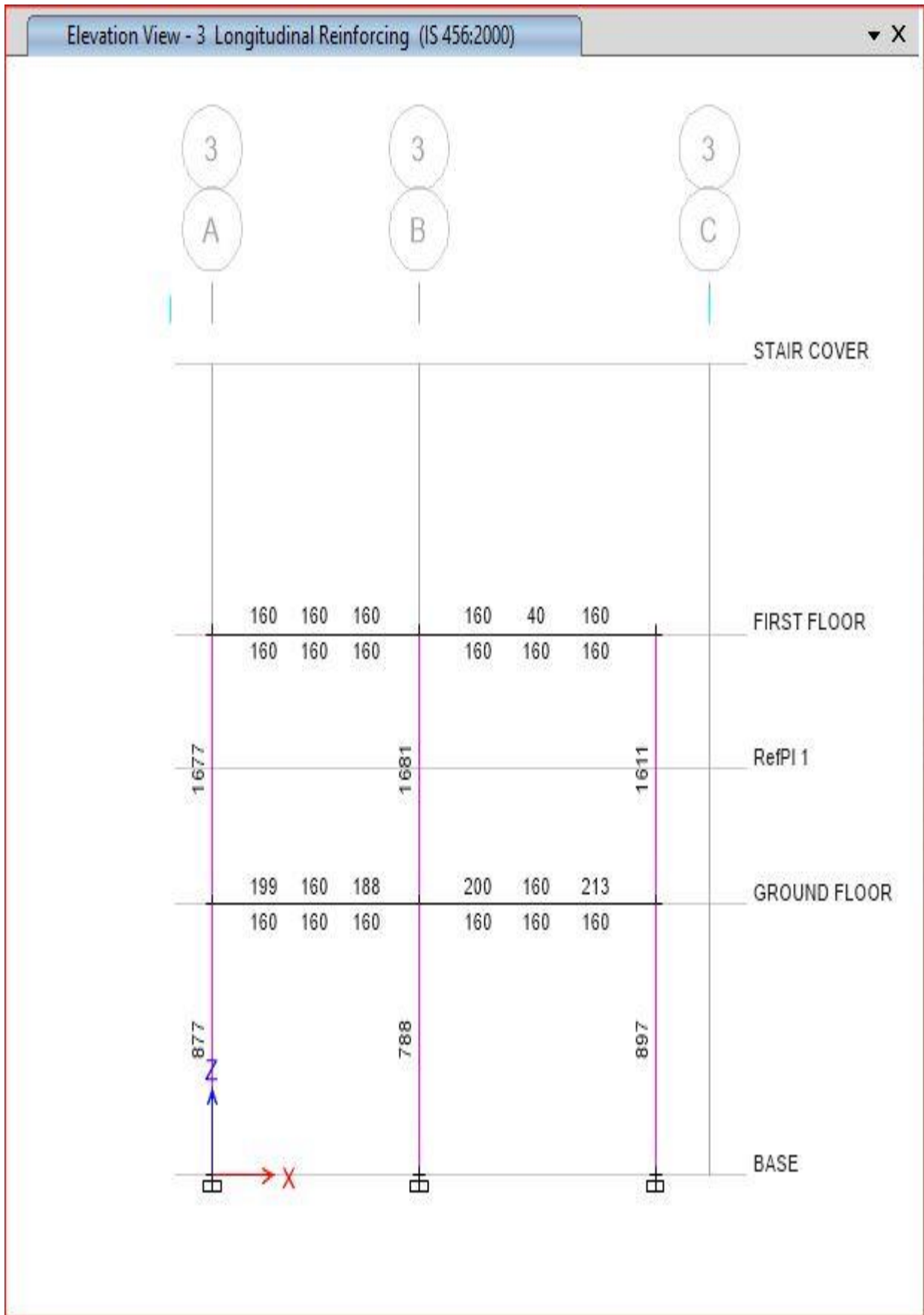
REINFORCEMENT OUTPUT



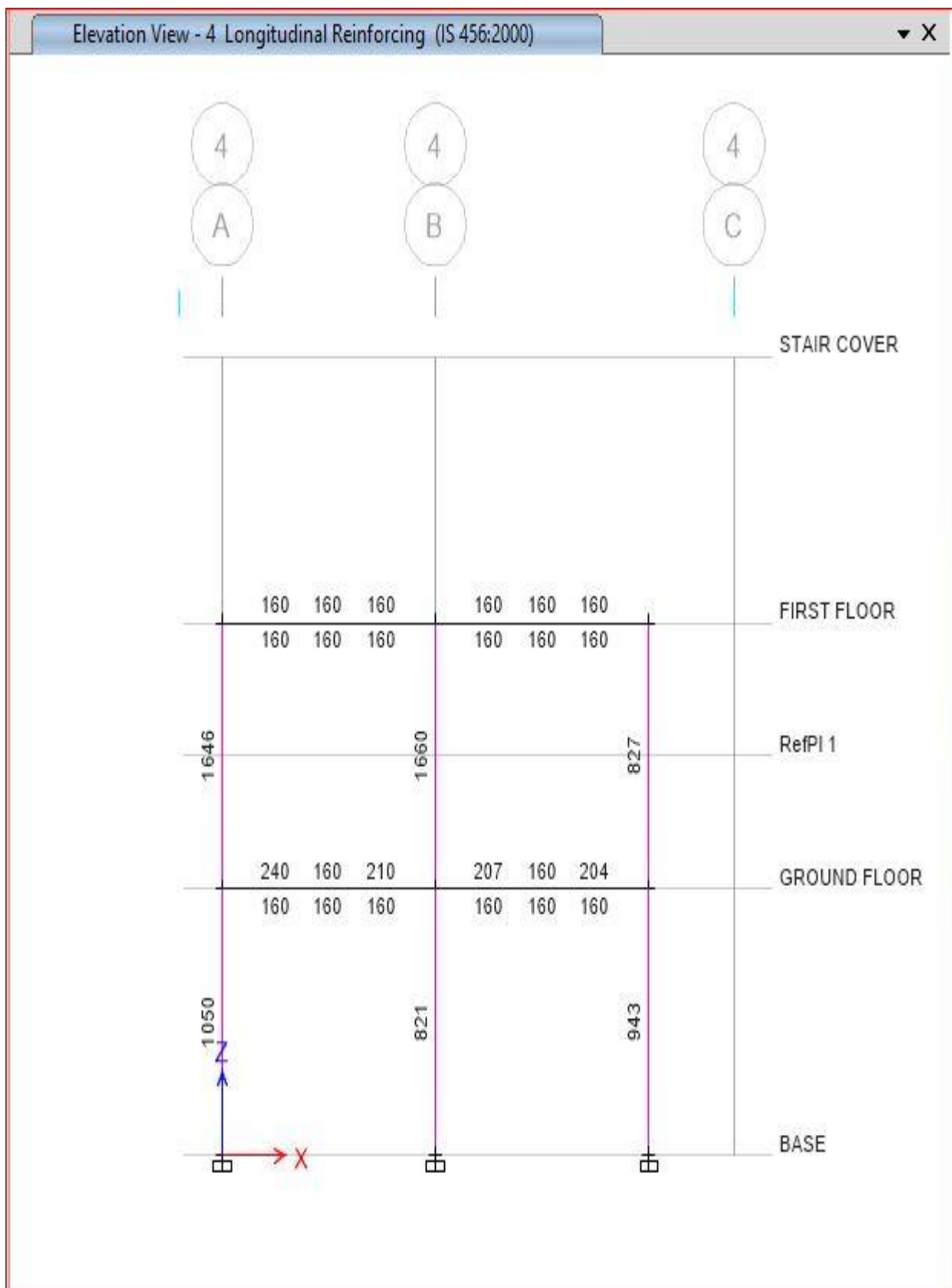
ELEVATION ALONG-1



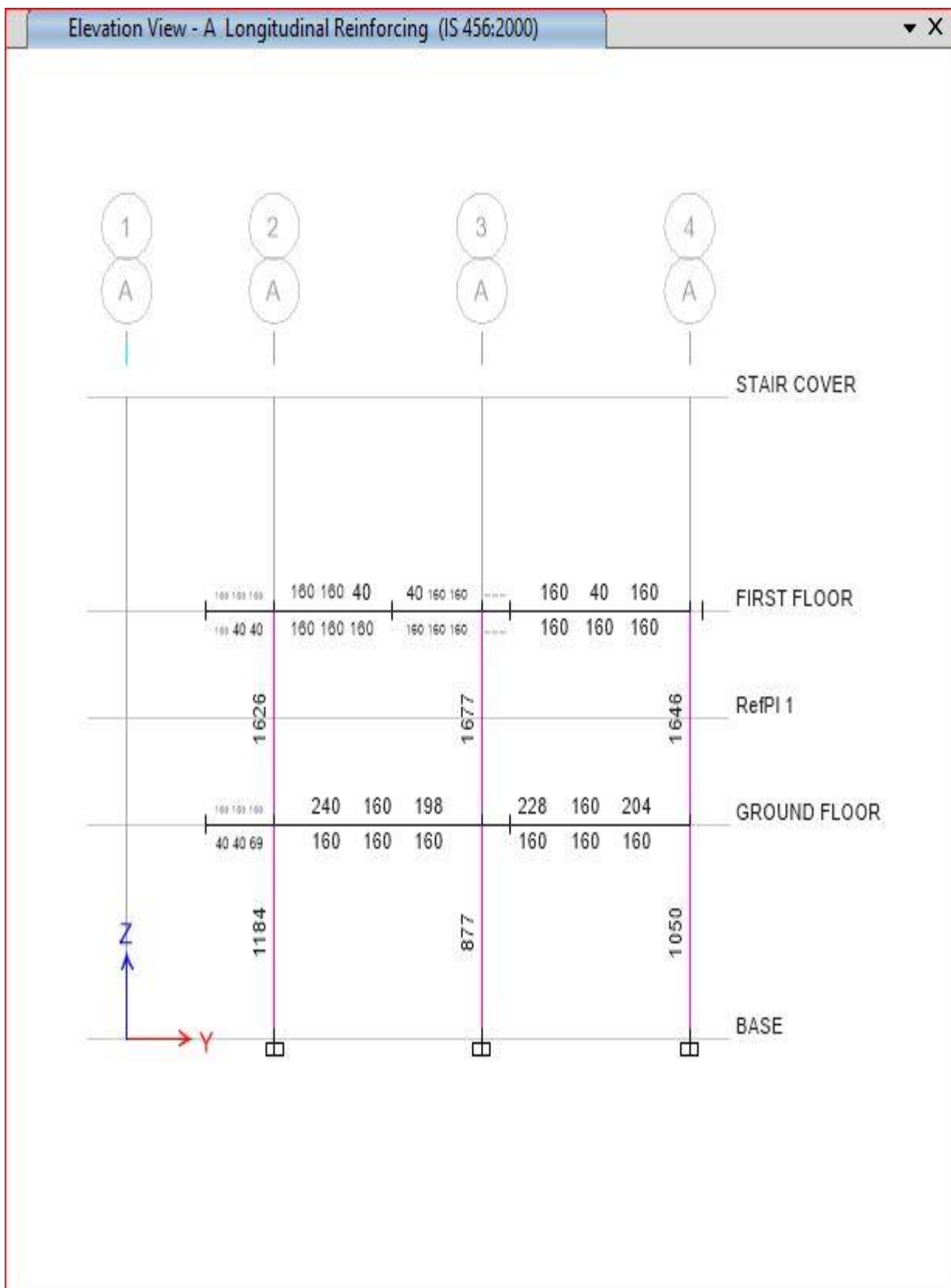
ELEVATION ALONG-2



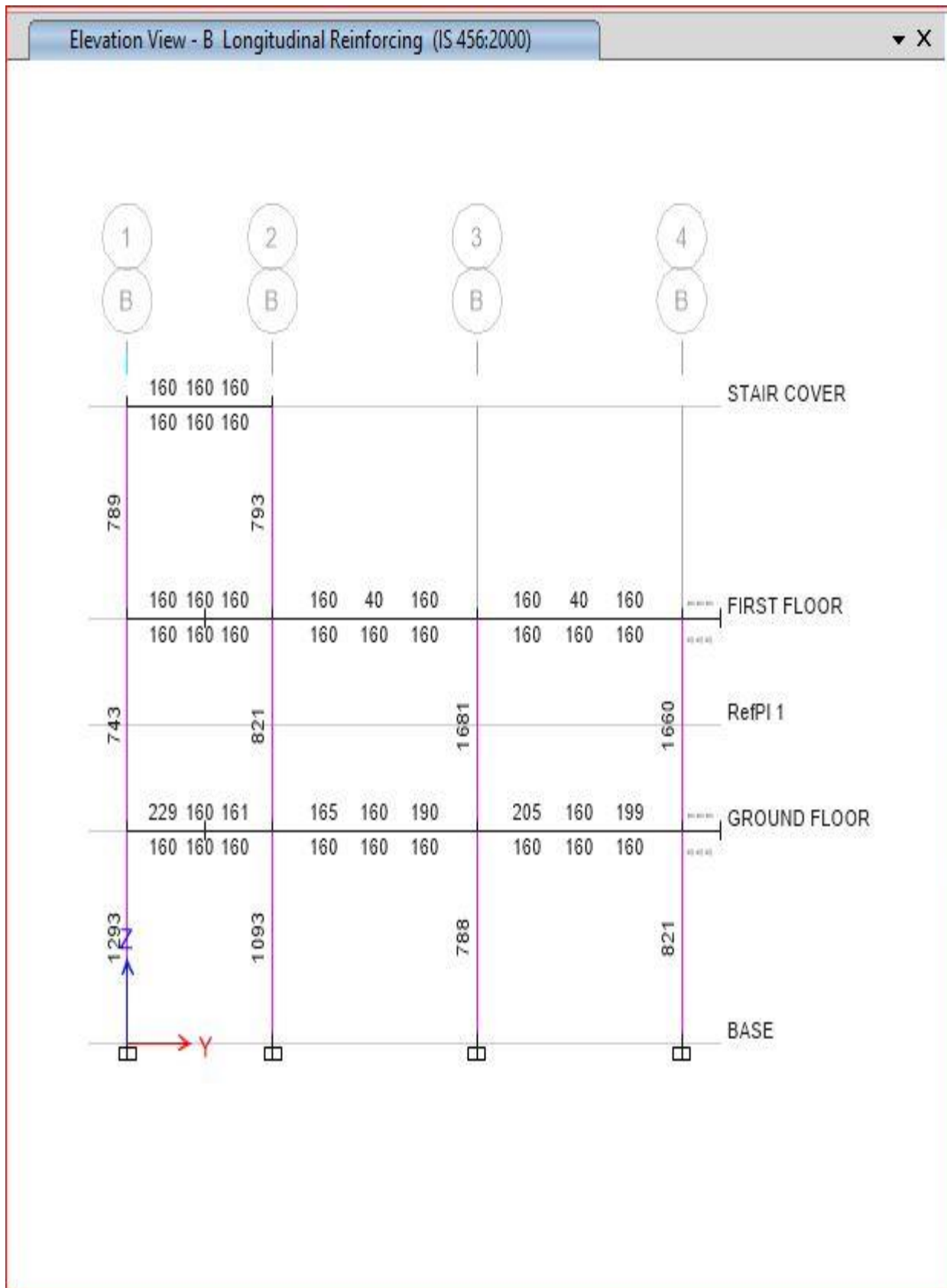
ELEVATION ALONG-3



ELEVATION ALONG-4



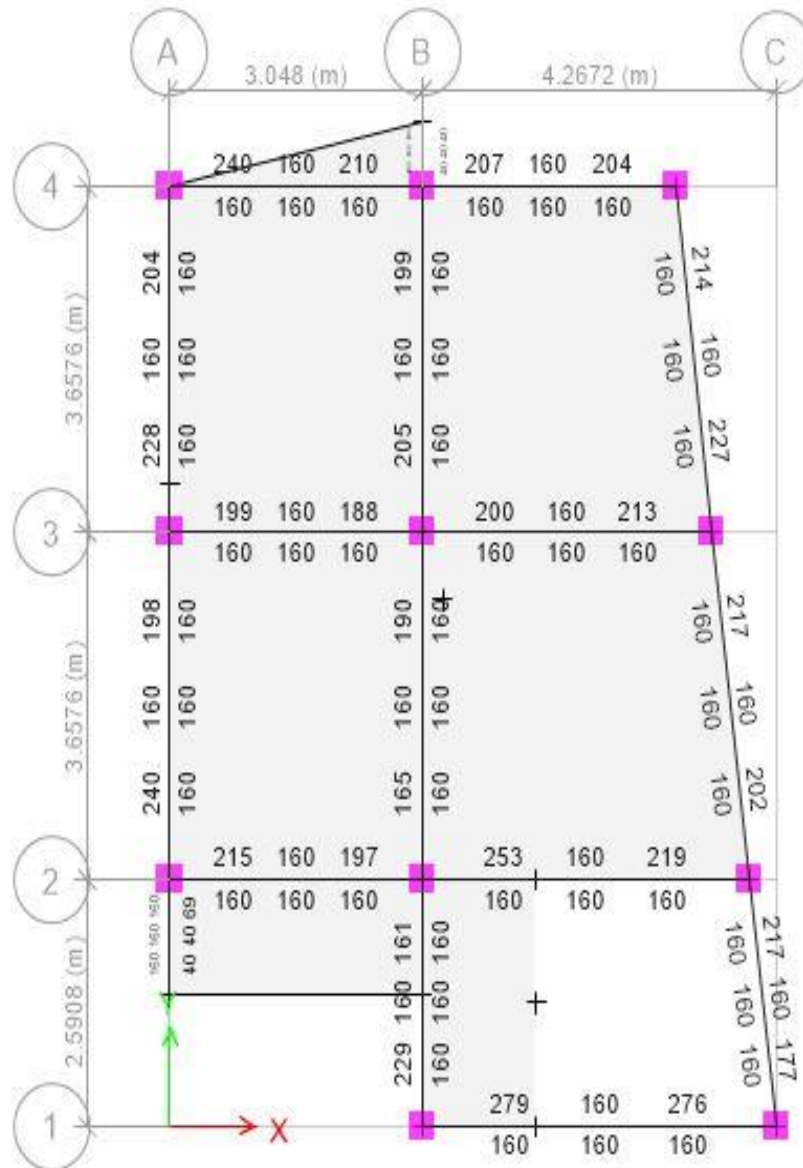
ELEVATION ALONG -A



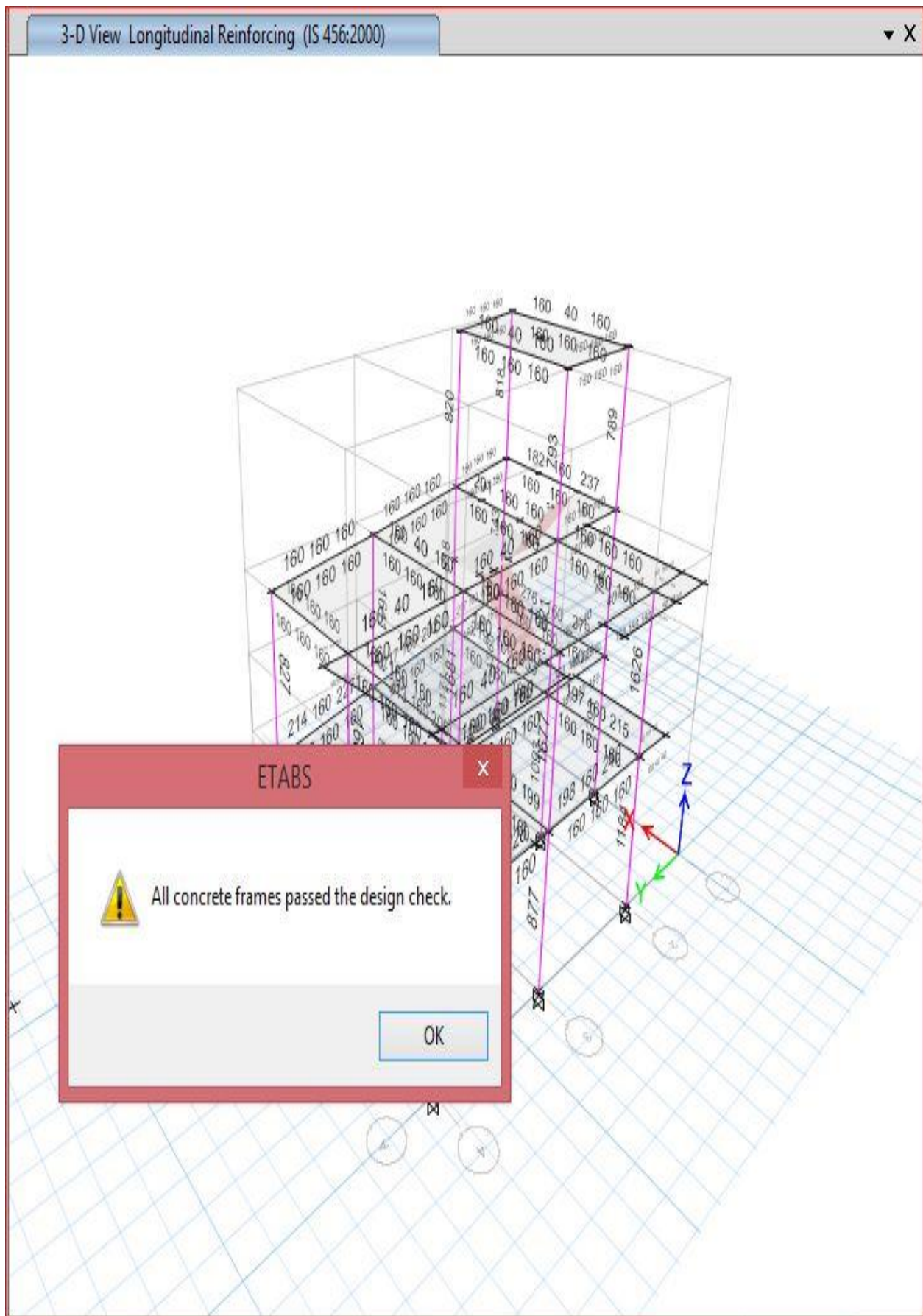
ELEVATION ALONG-B

Plan View - GROUND FLOOR - Z = 2.8448 (m) Longitudinal Reinforcing (IS 456:2000)

X



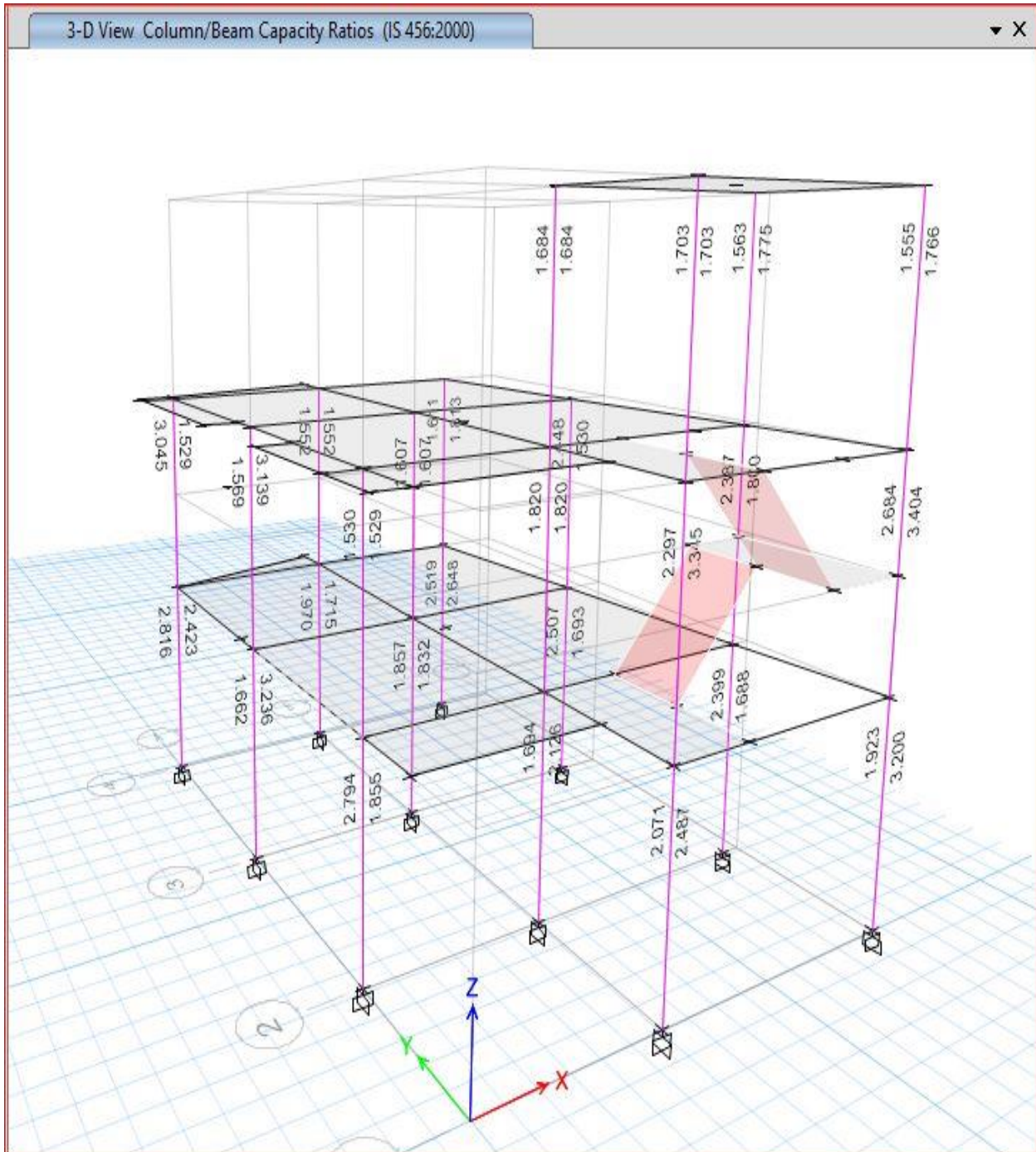
GROUND FLOOR REINFORCEMENT



According to NBC :105:2020, as per clause 4.4.4

at every beam column junction in a frame, the summation of the moment capacities of the column end section shall be greater than 1.2 times the summation of the beam end capacities.

i.e. $(\sum M_c / \sum M_b) > 1.2$ 4.4.4



COLUMN-BEAM CAPACITY

Design of structural members

Column Design

Design Loads

Load	Pu	83 KN
Moment	Mu	81 KN-m

Column Data

width	b	305 mm
depth	d	305 mm
length	l	2.85 meters

Grade

Concrete	fck	20 MPa
Steel	fy	500 MPa

$P_u/(f_c k b d)$	0.04
$M_u/(f_c k b d^2)$	0.04
d'/d	0.05

Minimum eccentricity

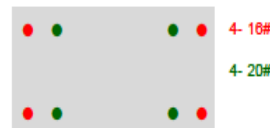
ex	1.59 mm	OK
ey	1.59 mm	OK

Refer Chart 35 of SP 16, Page no: 120

pt/fck	0.1
pt	2.00%
Ast	1858 sqmm

Number of bars

dia	nos	ast
16 mm	4	804 sqmm
20 mm	4	1257 sqmm
-	-	
Total	8	2061 sqmm



Steel provided OK

fy	d'/d	Chart No.	Page No
250	0.05	Chart 27	112
	0.1	Chart 28	113
	0.15	Chart 29	114
	0.2	Chart 30	115
415	0.05	Chart 31	116
	0.1	Chart 32	117
	0.15	Chart 33	118
	0.2	Chart 34	119
500	0.05	Chart 35	120
	0.1	Chart 36	121
	0.15	Chart 37	122
	0.2	Chart 38	123
	250	Chart 27	
	415	Chart 31	
	500	Chart 35	
Chart No.		Page No	
Chart 35		120	

Beam Design

Beam Data

width	229 mm
depth	356 mm
clear cover to main	30 mm

d'	48 mm	$\therefore cc + sdia + mdia/2$
eff depth	308 mm	$\therefore d - d'$

Material Grades

Concrete	20 MPa
Steel	415 MPa

Moment	36 KN-m
--------	---------

Mu/bd ²	1.65	
x _{max}	147	$\therefore (700/(1100 * (0.87 * f_y))) * d$
M _{ulim}	60	$\therefore 0.36 * f_{ck} * b * x_{max} * (d - (0.42 * x_{max}))$
M _{ulim} /bd ²	2.76	

Beam is designed as Singly Reinforced Beam

Area of Steel	Tension (Ast)	Compr (Asc)
Percentage	0.512 %	-----
Area of Steel	360 sqmm	

Refer Table 2 SP 16 pg 48

Tension Reinforcement

Type	Bar dia	Nos	Area of Steel
Layer 1	20 mm	2	628 sqmm
Layer 2	-	0	
Layer 3	-	0	

Total Steel Provided 628 sqmm 0.894 %
Provided Steel OK

Compression Reinforcement

Type	Bar dia	Nos	Area of Steel
Layer 1	16 mm	2	
Layer 2	-	0	
Layer 3	-	0	

Total Steel Provided #VALUE!

Shear Force (Vu)	43 KN
------------------	-------

ζ _v	0.611	$\therefore Vu / (b * d)$	
ζ _c	0.281	Refer Table 61 SP 16 pg 179	or $\therefore (0.85 * v(0.8 * f_{ck}) * v(1 + 5 \beta) - 1)) / (6 \beta)$
ζ _{cmax}	2.8	Refer Table J SP 16 pg 175	

Type	Bar Dia	Nos	Area of Steel
Layer 1	8 mm	2	101 sqmm
Layer 2	-	0	
Layer 3	-	0	
Total Steel Provided			101 sqmm

0.143 %

Sectional Dimensions OK

Shear Reinforcements required

Type of stirrup	2 legged
Stirrup diameter	8 mm
Spacing	231 c/c

Hence, Provide Two legged 8 mm Dia @150 mm c/c spacing

Slab Design

Slab thickness	t	127 mm
Concrete	f _{ck}	20 MPa
Steel	f _y	500 MPa

Sunken Depth	0 mm
--------------	------

Loading

Slab Load		
Dead Load	DL	3.080 KN/m
Live Load	LL	2.000 KN/m
Finishes Load	WL	1.000 KN/m
Total Load	W _s	6.080 KN/m
Factored Load	W _{su}	9 KN/m

Sunken Slab Load		
Dead Load	DL	0.000 KN/m
Filler Load	FL	0 KN/m
Live Load	LL	0.0 KN/m
Finishes Load	WL	0.0 KN/m
Total Load	W _{sk}	0.00 KN/m
Factored Load	W _{sku}	0 KN/m

Slab Data

Slab Type	Regular
Load	9 KN/m
Longer Span (l _y)	3.65 m
Shorter Span (l _x)	3.05 m

l _y /l _x ratio	1.20
Slab type	+

Loading on edges		one way	two way
W _{longer}	11 KN/m	$= w \cdot l_x / 2$	$= (w \cdot l_x / 2) + (1 - (1/3) \cdot (l_x / l_y)^2) \cdot w \cdot l_x / 2$
W _{shorter}	9 KN/m	$= w \cdot l_x / 3$	

Moments		one way	two way
M _x	6 KN-m	$= w \cdot l_x^2 / 8$	$= \alpha_x \cdot w \cdot l_x^2$
M _y	5 KN-m		$= \alpha_y \cdot w \cdot l_x^2$

Thickness Check	OK	$= M_{ulim} > M_{ux} \text{ or } M_{uy}$
Deflection	6 mm	$= 5 \cdot W \cdot l^4 / (384EI)$

Area of Steel	A _{stx}	A _{sty}	Refer Chart 4 SP 16 pg 21 or Refer Table 5-44 SP 16 pg 51-80
	135 sqmm	152 sqmm	

Spacing required in mm

8#		10#		12#		16#	
x	y	x	y	x	y	x	x
372 c/c	330 c/c	582 c/c	515 c/c	838 c/c	742 c/c	1490 c/c	1319 c/c

$= a_{st} \cdot \text{bar} \cdot 1000 / a_{st} \text{ req}$

Final Ast provided	x	y
	10 mm @ 150 mm c/c	10 mm @ 150 mm c/c

Staircase Design

Data

Effective Span (l)	4.49 meters
Riser (R)	178 mm
Thread (T)	254 mm
Waist Slab thickness (t)	150 mm
Clear Cover	15 mm
Effective Depth of Waist Slab (d)	135 mm

Grade of Concrete (f _{ck})	20 MPa
Grade of Steel (f _y)	500 MPa

Loading

Loads on going

Self weight of waist slab	3.90 KN/m
Self weight of steps	2.00 KN/m
Live Load	3.00 KN/m
Floor Finish Load	1.00 KN/m
Total Load	9.90 KN/m
Factored Load	14.85 KN/m

Loads on waist slab

Self weight of landing slab	3.90 KN/m
Live Load	3.00 KN/m
Floor Finish Load	1.00 KN/m
Total Load	7.90 KN/m
Factored Load	11.85 KN/m

Bending Moment

☒ Calculate Bending Moment using the equation $(W \cdot L^2 / 8)$

Bending Moment = 37 KN-m

Reaction

to be used as UDL = 33 KN

Area of Main Steel

A_{st} = 739 sqmm

Spacing

Diameter of bar	12Ø	16Ø
Spacing across x	153 c/c	272 c/c

Provided Main Steel: 12 mm Dia @ 125 mm c/c

Area of Distribution Steel

A_{st} = 180 sqmm

Spacing

Diameter of bar	8Ø	10Ø
Spacing across y	279 c/c	436 c/c

Provided Distribution Steel: 10 mm Dia @ 100 mm c/c

1 Footing Size Design

Load	Pu	297 KN
Design Load	P	218 KN
Moment In x dir	Mux	1 KN-m
Moment In y dir	Muy	1 KN-m
Column size	cx	305 mm
	cy	305 mm
SBC	q	150 KN/sqm
Footing Size required	A req	1.45 sqmm
Footing Size Provided	L	1.50 meters
	B	1.50 meters
Area Provided	A prvd	2.25 meters
	Zx	0.56
	Zy	0.56
Net upward pressure	Nup	100 KN/m ²

Footing Size OK

2 Slab Design

	lx	0.598
	ly	0.598
Bending Moment In x dir	Mx	27 KN-m
Bending Moment In y dir	My	27 KN-m
Concrete	fck	20 MPa
Steel	fy	500 MPa
Minimum Depth Required	dmin	100
Depth Provided	D	450 mm
Clear Cover	c	40 mm
Effective Cover	d'	46 mm
Effective Depth	d'	404 mm

Area of Steel	Spacing c/c In mm		
	12#	16#	20#
485 sqmm	233 c/c	415 c/c	648 c/c
485 sqmm	233 c/c	415 c/c	648 c/c

Minimum Ast required across x direction

Minimum Ast required across y direction

Ast across x direction	12 mm dia @ 125 mm c/c	905 sqmm
Ast across y direction	12 mm dia @ 125 mm c/c	905 sqmm

3 One Way Shear along x direction

V_{u1}	44 KN
ζ_v	0.072 MPa
ζ_c	0.260 MPa

V_{c1}	158 KN
----------	--------

One Way Shear Check OK

4 One Way Shear along y direction

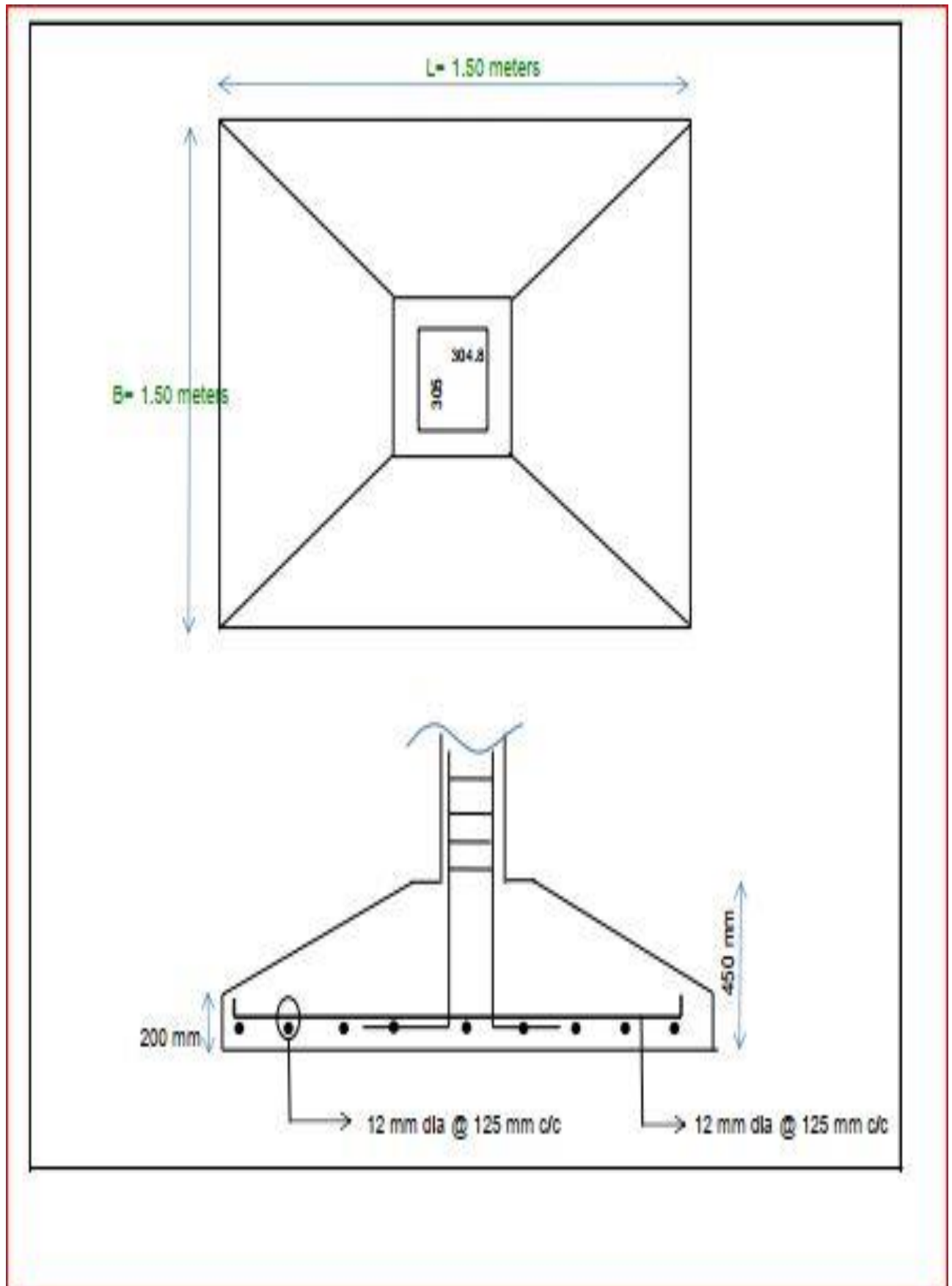
V_{u1}	44 KN
ζ_v	0.072 MPa
ζ_c	0.260 MPa
V_{c1}	158 KN

One Way Shear Check OK

5 Two Way Shear

V_{u2}	262 KN
ζ_v	0.229 MPa
$k_s \cdot \zeta_c$	1.118 MPa
V_{c1}	1281 KN

Two Way Shear Check OK



ETABS Concrete Frame Design

IS 456:2000 + IS 13920:2016 Beam Section Design (Envelope)

Beam Element Details

Level	Element	Unique Name	Section ID	Length (mm)	LLRF
GROUND FLOOR	B9	20	BEAM 9"X14"	4267.2	1

Section Properties

b (mm)	h (mm)	b _f (mm)	d _s (mm)	d _{ct} (mm)	d _{cb} (mm)
228.6	355.6	228.6	0	30	30

Material Properties

E _c (MPa)	f _{ck} (MPa)	Lt.Wt Factor (Unitless)	f _y (MPa)	f _{ys} (MPa)
22360.68	20	1	500	500

Design Code Parameters

γ _c	γ _s
1.5	1.15

Flexural Reinforcement for Major Axis Moment, M_{u3}

	End-I Rebar Area mm ²	End-I Rebar %	Middle Rebar Area mm ²	Middle Rebar %	End-J Rebar Area mm ²	End-J Rebar %
Top (+2 Axis)	279	0.34	160	0.2	276	0.34
Bot (-2 Axis)	160	0.2	160	0.2	160	0.2

Flexural Design Moment, M_{u3} (Part 1 of 2)

	End-I Design M _u kN-m	End-I Station Loc mm	Middle Design M _u kN-m	Middle Station Loc mm
Top (+2 Axis)	-35.7071	152.4	0	2743.2
Combo	DL+0.3LL-EQxULS-0.3EQyULS		DL+LL-FOOTING	
Bot (-2 Axis)	4.744	1097.2	8.1656	2743.2
Combo	DL+LL-FOOTING		DL+LL-FOOTING	

Flexural Design Moment, M_{u3} (Part 2 of 2)

End-J Design M _u kN-m	End-J Station Loc mm
-35.7847	4114.8
DL+0.3LL+EQxULS-0.3EQyULS	
0	4114.8
DL+LL-FOOTING	

Shear Reinforcement for Major Shear, V_{u2}

End-I Rebar A _{sv} /s mm ² /m	Middle Rebar A _{sv} /s mm ² /m	End-J Rebar A _{sv} /s mm ² /m
305.07	253.39	365.98

Design Shear Force for Major Shear, V_{u2}

End-I Design V_u kN	End-I Station Loc mm	Middle Design V_u kN	Middle Station Loc mm	End-J Design V_u kN	End-J Station Loc mm
35.7108	152.4	0.0074	2743.2	42.935	4114.8
DL+0.3LL+EQxULS+0.3EQyULS		DL+LL-FOOTING		DL+0.3LL-0.3EQxULS-EQyULS	

Torsion Reinforcement

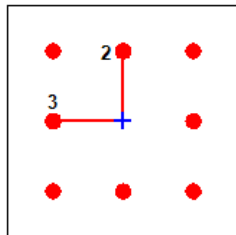
Shear
Rebar A_{svt} /s
mm²/m
0

Design Torsion Force

Design T_u kN-m	Station Loc mm	Design T_u kN-m	Station Loc mm
0.0172	274.3	0.0172	274.3
DL+0.3LL-EQxULS-0.3EQyULS		DL+0.3LL-EQxULS-0.3EQyULS	

ETABS Concrete Frame Design

IS 456:2000 + IS 13920:2016 Column Section Design



Column Element Details Type: Ductile Frame (Summary)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF
FIRST FLOOR	C6	37	COLUMN 12"X12"	DL+0.3LL-0.3EQxULS-EQyULS	2489.2	2844.8	0.852

Section Properties

b (mm)	h (mm)	dc (mm)	Cover (Torsion) (mm)
304.8	304.8	60	30

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
22360.68	20	1	500	500

Design Code Parameters

γ_c	γ_s
1.5	1.15

Axial Force and Biaxial Moment Design For P_u , M_{u2} , M_{u3}

Design P_u kN	Design M_{u2} kN-m	Design M_{u3} kN-m	Minimum M_2 kN-m	Minimum M_3 kN-m	Rebar Area mm ²	Rebar % %
82.8838	17.5856	61.0345	1.6577	1.6577	1681	1.81

Axial Force and Biaxial Moment Factors

	K Factor Unitless	Length mm	Initial Moment kN-m	Additional Moment kN-m	Minimum Moment kN-m
Major Bend(M3)	0.732913	2489.2	-4.0882	0	1.6577
Minor Bend(M2)	0.747902	2489.2	-7.4439	0	1.6577

Shear Design for V_{u2} , V_{u3}

	Shear V_u kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm ² /m
Major, V_{u2}	42.9095	54.5946	29.8462	42.9095	337.85
Minor, V_{u3}	42.9095	54.5946	29.8462	42.9095	337.85

Joint Shear Check/Design

	Joint Shear Force kN	Shear V_{Top} kN	Shear $V_{u,Tot}$ kN	Shear V_c kN	Joint Area cm ²	Shear Ratio Unitless
Major Shear, V_{u2}	0	0	138.9374	415.475	929	0.334
Minor Shear, V_{u3}	0	0	138.9374	415.475	929	0.334

(1.4) Beam/Column Capacity Ratio

Major Ratio	Minor Ratio
0.87	0.87

Additional Moment Reduction Factor k (IS 39.7.1.1)

A_g cm ²	A_{sc} cm ²	P_{uz} kN	P_b kN	P_u kN	k Unitless
929	16.8	1466.5911	287.06	82.8838	1

Additional Moment (IS 39.7.1)

	Consider M_a	Length Factor	Section Depth (mm)	KL/Depth Ratio	KL/Depth Limit	KL/Depth Exceeded	M_a Moment (kN-m)
Major Bending (M_3)	Yes	0.875	304.8	5.985	12	No	0
Minor Bending (M_2)	Yes	0.875	304.8	6.108	12	No	0

13. General Notes

NOTES

A. GENERAL

1. READ STRUCTURAL DRAWING IN CONJUNCTION WITH ARCHITECTURAL DRAWING. REPORT ANY DISCREPANCIES TO THE SITE ENGINEER PRIOR TO FABRICATION OR CONSTRUCTION. ANY CONFLICT BETWEEN SPECIFICATION & DRAWING SHALL BE LIKEWISE REPORTED.
2. CONTRACTORS SHALL BE RESPONSIBLE FOR CHECKING FIELD DIMENSION & SITE CONDITIONS.
3. UNLESS OTHERWISE INDICATED ALL CONSTRUCTION JOINTS SHALL BE ROUGHENED JOINTS 5mm (AMPLITUDE MINIMUM 5mm.).
4. NO MEASUREMENT SHALL BE DIRECTLY TAKEN FROM THE PRINT, WRITTEN DIMENSION SHALL BE FOLLOWED.

B. FOUNDATION

1. FOUNDATION SHALL BE ON UNDISTURBED SOIL.
2. SOIL BEARING CAPACITIES SHALL BE VERIFIED IN THE FIELD NOTIFIED ENGINEER IMMEDIATELY OF ANY SOFT POCKETS OR OTHER ADVERSE SOIL CONDITIONS ENCOUNTERED.
3. THE LINE OF SLOPE BETWEEN ADJACENT EXCAVATIONS FOR FOOTING OR ALONG STEPPED FOOTING SHALL NOT EXCEED A RISE 1 IN A RUN OF 2.
4. PLACING OF FOUNDATION CONCRETE SHALL BE DONE AS SOON AS EXCAVATIONS HAVE BEEN COMPLETED & APPROVED BY THE SITE ENGINEER.

C. CONCRETE & REINFORCING STEEL

1. CAST-IN-SITU CONCRETE SHALL HAVE A MINIMUM 28 DAYS COMPRESSIVE CUBE STRENGTH OF 25N/mm FOR COULMN AND 20 N/mm FOR OTHER STRUCTURAL MEMBER.
2. REINFORCING STEEL SHALL BE NEW TMT STEEL BARS HAVING A MINIMUM YIELD STRENGTH OF 500N/mm FOR COULMN , 500N/mm FOR OTHER STRUCTURE & CONFORMING TO IS 1786:1979 OR IS 1139:1963. MINIMUM REINFORCING LAPS SHALL BE IN ACCORDANCE WITH IS 1786:1979 & AS SPECIFIED ON STRUCTURAL DRAWING.
4. COVER TO MAIN REINFORCING STEEL BE IN ACCORDANCE WITH IS 456:1978 & AS SPECIFIED ON STRUCTURAL DRAWING.

5. CLEAR COVER OF CONCRETE :-

SLAB	= 20mm
STAIRCASE	= 20mm
BEAM	= 30mm
COLUMN	= 40mm
FOOTING	= 50mm
RCC WALL	= 20mm

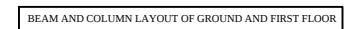
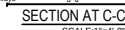
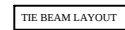
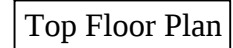
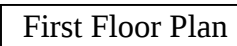
PROVIDE CORNER BARS TO MATCH HORIZONTAL REINFORCING STEEL IN SLAB.

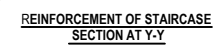
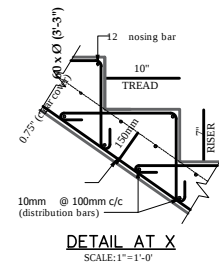
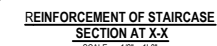
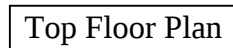
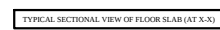
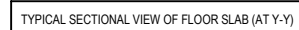
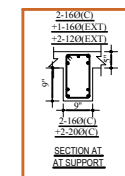
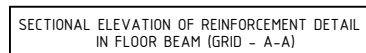
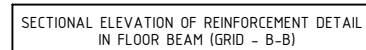
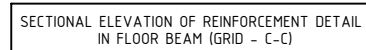
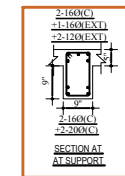
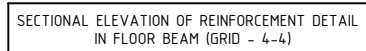
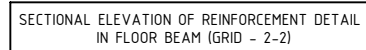
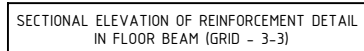
6. PLUMBING, SLOTS, HOLES, AROUND PIPES DUCTS OR OTHER ITEMS WHICH PASS THROUGH CONCRETE SLAB OR WALL SHALL BE FILLED & PATCHED TO THE SAME DEPTHS AS THE SLAB OR WALL.
7. UNLESS OTHERWISE INDICATED ALL HORIZONTAL & VERTICAL CONSTRUCTION JOINTS SHALL BE ROUGHENED JOINTS WITH 5mm MINIMUM AMPLITUDE.
8. THE CEMENT USED SHALL BE ORDINARY PORTLAND CEMENT CONFORMING TO IS 269:1976.

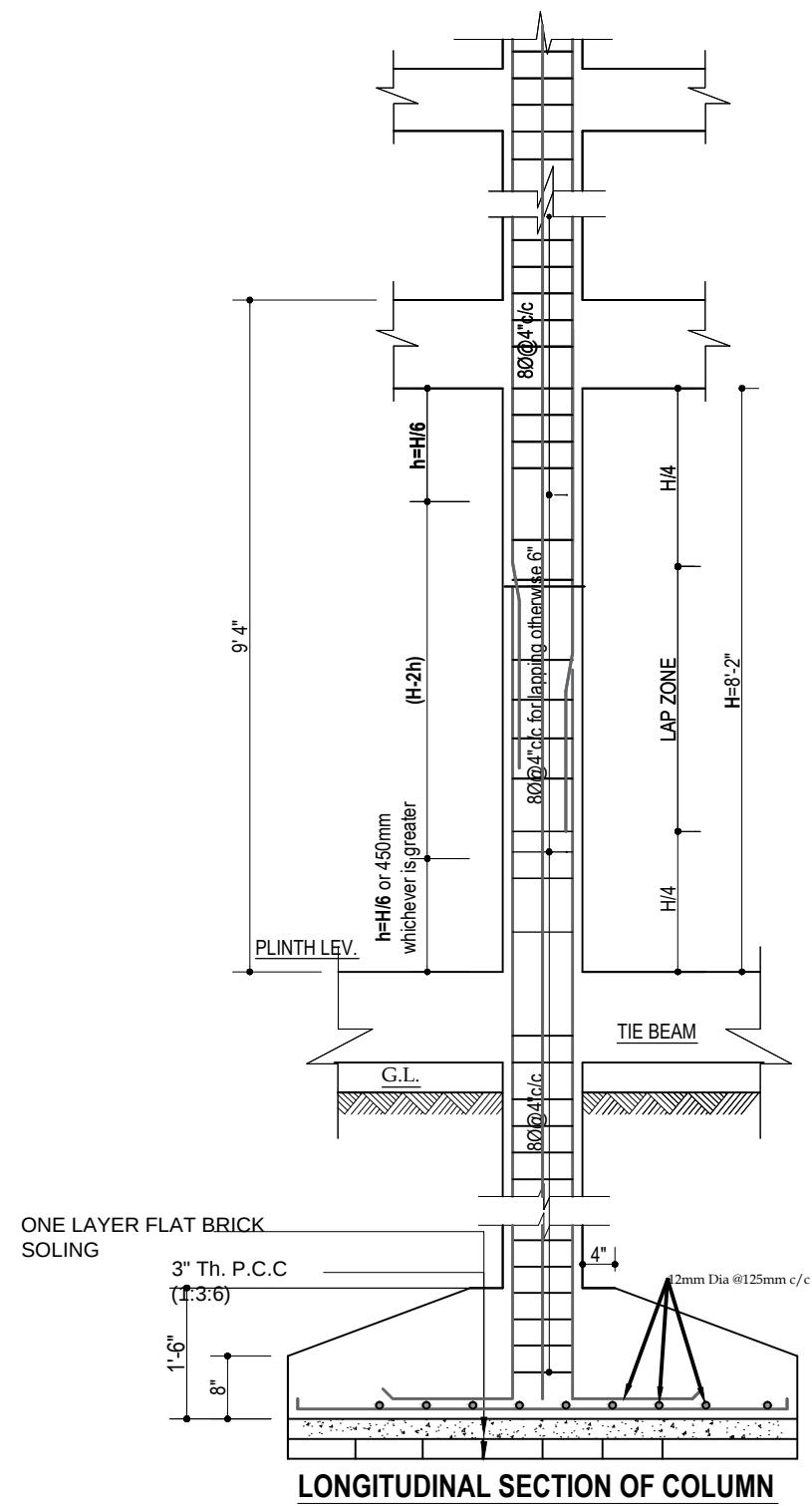
9. BAR BENDING SCHEDULE SHALL BE SUBMITTED FOR APPROVAL BEFORE CASTING CONCRETE.

14. References

- 1.0 IS code 456-2000: Plain and Reinforced Concrete code of Practice
- 2.0 IS code 1893 (part I)-2002: Criteria for earthquake Resistant Design of Structures
- 3.0 IS code 875-1987: Code Of Practice For Design Loads
 - Part 1 Dead Loads
 - Part 2 Imposed Loads
 - Part 5 Special loads and Load combination
- 4.0 IS code 13920-1993: Ductile Detailing of RCC structures subjected to seismic force- Code of practice
- 5.0 Nepal National Building Code (NBC 105:2020): Seismic Design of Buildings in Nepal.
- 6.0 RCC structures by A.K. Jain
- 7.0 RCC structures by S.N. Sinha
- 8.0 Limit State Design by Vargees
- 9.0 Structural Design of Multistoried building by U.H. Varyani
- 10.0 IS code SP 16 Design guidelines for RCC Structures
- 11.0 IS code SP 34 for detailing of RCC structures

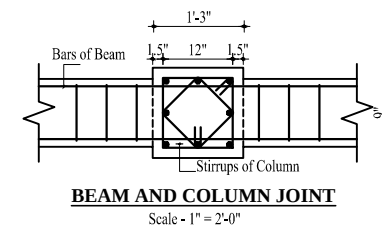






Development length	
DIA. (Ø)	Ld.
8	1'-9"
10	2'-0"
12	2'-6"
16	3'-3"
20	4'-0"

Ld. = Development length



CLEAR COVER OF CONCRETE :	
SLAB	= 15mm
STAIRCASE	= 15mm
BEAM	= 25mm
COLUMN	= 40mm
FOOTING	= 75mm

